

# SCIENTIFIC AMERICAN

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### NEW ROTARY PRINTING PRESS FOR ILLUSTRATED PAPERS.

THE MESSRS. ALAUZET & Co. of Paris exhibited at the Exhibition a new press, solving a problem heretofore considered almost impossible to be solved by printers and mechanical constructors, the problem of applying all the modern improvements made on printing presses for newspapers of large circulation and several daily editions to presses destined to print periodicals with illustrations of artistic value. Without entering into technical details, we only point out what was principally required: greater rapidity, reduction of manual assistance in fixing the margin, feeding the sheets, receiving them when printed, and cutting and folding them for distribution. All these points being covered, even the most elaborate engravings in wood, steel, copper, etc., must be able to be used, and produce clear, correct impressions, without being themselves injured in the least. This to attain with the presses used for daily papers for years is

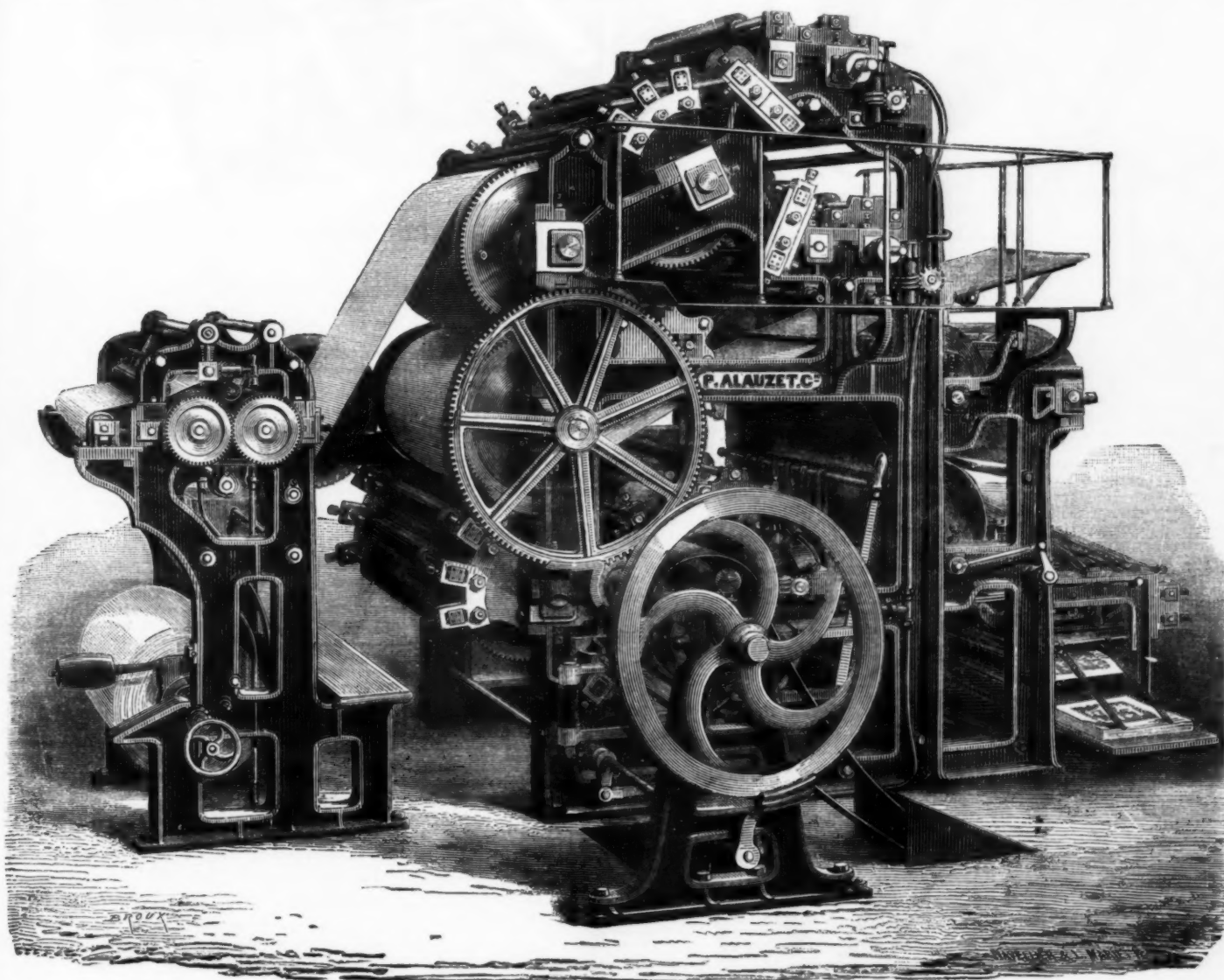
### A CALIFORNIAN JEWEL CASKET.

ONE of the most curious and at the same time most interesting objects of the Transatlantic collection is that sent by Mrs. A. Sunderland, of California, a lady who is so well endowed with this world's goods that she has been enabled to spend no less than £6,000 on a jewel casket, powder box, and portemonnaie. It is these peculiarly feminine luxuries that Mrs. Sunderland has been induced to contribute to the Exhibition, for the simple reason that, not only are they representative of the jeweler's art at San Francisco, but that they also exhibit the quality of the auriferous resources of California. The portemonnaie is made of solid gold and quartz rock, in mosaic, beautifully interspersed with gold. The quartz rock used in this and the other articles comes from mines of California, Nevada, Arizona, and Washington Territory.

The jewel casket represents the substantial wealth of the mines on the Pacific coast, being made entirely of gold and

beautifully inlaid with gold quartz in the finest mosaic work, hundreds of pieces being required for the construction of this exquisite cover. The most elegant part of the whole casket is the exquisite piece of workmanship on the inside of the cover. It is a pictorial and historical representation of a buffalo hunt on the plains. The engraving of the landscape is very fine, the shrubbery and trees being in bass-relief. In the foreground is the railway track, with two buffaloes dashing across it to evade the hunters, who are in close pursuit. All this is in alto-relievo, and has great expression. The figures are not only correctly proportioned, but skillfully handled, and the whole representation is artistically wrought.

The powder box is composed of quartz rock, its shape being round and made to resemble a Greek dome. The top or cover is supported by eight columns of solid gold quartz rock, beautifully polished, each capped with pure gold. The cover, forming the roof of the dome, is exquisitely inlaid with quartz rock of variegated colors,



THE PARIS EXHIBITION—NEW ROTARY PRINTING PRESS OF M. ALAUZET.

impossible. Engravings require the utmost care in handling and printing, if they shall give a clear correct impression and not be speedily destroyed. These difficulties have been overcome by Mr. Alauzet in this press, of which we present an illustration to-day. We will not enter into a detailed description of the same; suffice it to say, that the inking is done in a superior manner, compared with ever the best presses so far in use; the continuity of the whole operation is unsurpassed, from the moment when the paper unwraps from the roll, till the ready cut and folded journals are deposited at the other extremity of the press. By an ingenious arrangement all waste by soiling or tearing is avoided. By a device patented by Mr. Alauzet, the clichés or cuts of the engravings are fastened and held in position without receiving the least injury, and producing a clean and perfect impression, no matter how large the edition of a journal may be. The press can furnish, already cut and folded, four thousand copies an hour of a journal of the same size and shape as ours.—*L'Illustration*.

gold quartz rock, from the mines of California, Oregon, Nevada, and Idaho. It required the steady work of five skillful artisans for six months for its completion. It is about 15 ins. long, ten inches wide, and about ten inches deep, and with the other articles, weighs nearly nineteen pounds. The casket for richness, beauty, and novelty has not been surpassed. It rests on four feet of solid gold, each of which represents the symbolic female figure that adorns the coat of arms of the State of California, with the grizzly bear at her side. The figures are in full relief and most elegantly formed, and constitute a salient feature of the beautiful work. The sides and ends of the casket are composed of solid slabs of gold quartz, highly polished, cut in spheroids, and are inlaid in solid gold, with ornamental surroundings. The four handsomely-wrought pillars on the sides are of Roman Doric style, which is artistically carried out in the entire work. The base of the casket is ornamented with graceful foliations. These are repeated upon the mouldings that finish the lid or cover. The top is of solid gold,

filled with the precious metal, and is bound on the edge with a solid rim of gold, the inside being lined with solid gold. The body of the box is made from one large mass of quartz rock, bored out, and elegantly polished on the outside, while the inside is lined throughout with solid gold, and rests on an ornamental base made of quartz rock mounted on gold. The whole is surmounted with the emblem of California, viz., the grizzly bear, which is represented as crossing the great overland railway. Thus civilization and savagery meet side by side. The powder puff is made of gold, and is in the truest taste. Two pounds of solid gold and the same quantity of gold quartz were required to make this *objet d'art*.—*III, Paris U. Exhibition*.

BOOMAH-NUTS, the fruit of *Pnecocoma macrophylla*, are imported from Natal as galls. They resemble Aleppo galls, but are less rich in tannin.

## FOWLER'S HAULING ENGINE.

We illustrate a very neat 12-inch double-cylinder hauling engine exhibited at Paris by Messrs. John Fowler & Co., of Leeds, and which we have already alluded to as almost the only stationary engine in the Exhibition made with wrought-iron framing. The general form of the engine is well shown in our engraving. The main framing is of plate and angle irons, fitted with cast-iron plunger block boxes at each end both of the drum and the cranks. The two cylinders (each 12 inches in diameter and 12-inch stroke) are cast together, and the connecting rods are coupled to a bent crankshaft (without middle bearing) which drives the drum shaft by spur gearing of 5 to 1, the shaft carrying a fly-wheel on the opposite end to the pinion. The drums (which

ciently large to receive the grain while the attendant is removing the full bag and applying another. By this means the work of filling the bag is dispensed with, and the labor of two men saved. The price is \$95.00.

EDWARD H. KNIGHT.

## INSTITUTION OF CIVIL ENGINEERS.

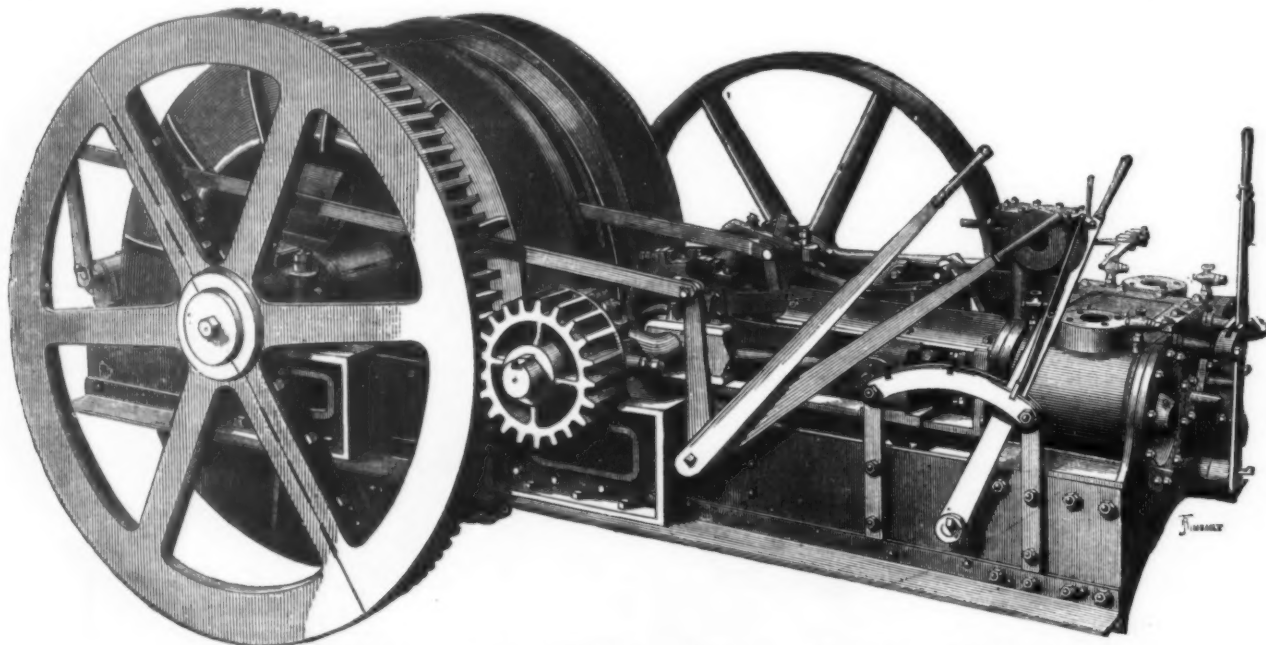
At the meeting, 12th of November London, Mr. W. H. Barlow, F.R.S., vice-president, in the chair, the first paper read was—

ON THE AVONMOUTH DOCK.

By Mr. J. B. MACKENZIE, M. INST. C.E.

Bristol at an early period of history was one of the chief

ter line of the lock, at an angle of 11 degs. 30 min. Rubble masonry faced with rough ashlar was employed. The walls were 49 ft. in height from the top of the footings to the coping, 33 ft 6 ins. wide at the base, and 7 ft. wide at the top. The face was battered to a radius of 150 ft., and the back had two steps 18 ins. and two 12 ins. wide. The footings were also of rubble masonry, and rested on sand; the inverts were of brick. The clear length between the inner and the outer gates was 454 ft. This length was divided by a pair of gates into two locks, the inner one being about 50 ft. longer than the outer one. The foundations of the lock were laid upon a bed of fine gray sand underlying clay at an almost uniform level, and at a depth of about 6 ft. under low water of equinoctial spring tides. The frequent occurrence of springs in this sand was the source of some trouble



UNDERGROUND HAULING ENGINE AT THE PARIS EXHIBITION.

are 48 inches in diameter and 12½ inches wide) are loose on the shaft, and are driven through a double-faced crab clutch feathered on the shaft between them; the clutch can be disengaged or put into gear with either drum by means of the hand lever shown at the back of the cylinders. The lever with catch rod beside the cylinders is the reversing lever, and the two long levers nearer the shaft are for the brakes, which are plain iron straps working on projecting drums cast on the main drums.

The length of the engine over all is 16 feet and its breadth 7 feet. It is neatly and strongly made by a firm which knows what it is to make an engine to stand rough work. We understand that it has been designed specially, so that if necessary it may be worked underground by compressed air instead of steam.—*Engineering*.

## ENGLISH FANNING MILL, ELEVATOR, AND WEIGHING MACHINE.

The French have nothing to learn from us in the matter of cleaning grain from dirt, light grain, and weed seeds, and the same might be said of the English. The French grain cleaners, however, owing to certain peculiarities of their mode of cultivation, are more complicated and curious than those

shipping ports in the kingdom. Down to the era of ocean steamers, it was accounted only second in importance to the port of London, but subsequently declined to a comparatively subordinate rank. The paper described various schemes by different engineers for the improvement of the port from the time of Smeaton to the year 1860, of which only one by Jessop had been carried out. In 1864, Mr. Brunlees, V.P. Inst. C.E., recommended a scheme for a dock at the mouth of the Avon, which had been previously suggested. It was undertaken by the Bristol Port and Channel Dock Company in 1868 and was completed in 1877. The dock was on the Gloucestershire side of the Avon; from the anchorage of King road in the Bristol Channel to the entrance lock the distance was only 1,000 yards. The entrance channel from the Avon to the lock was about 350 yards in length by an average width of 70 yards, with a depth at high water of equinoctial spring tides of 44 ft., and of 40 ft. at ordinary spring tides. The dock was 1,400 ft. in length and 500 ft. in width, giving a water area of about 16 acres, and a length of quay wall of 3,200 ft. The south end was not protected by a wall, but was finished off with a slope of 2½ to 1. The range of an ordinary spring tide was 39 ft., while that of an ordinary neap tide was 19 ft. A special feature of the tides was the quantity of mud which the water held in suspen-

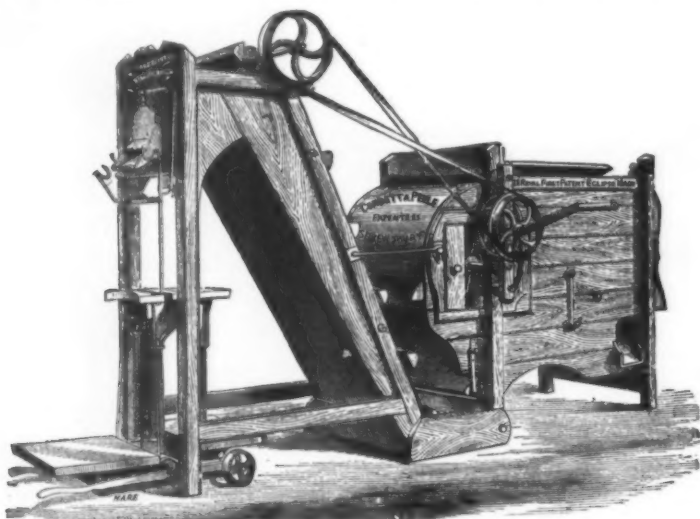
and difficulty. The apron in front of the lock was a mass of lime concrete, mixed with blocks of stone of 2 tons to 3 tons weight, and surrounded by walls of Portland cement concrete. The lock gates consisted of oak heel and miter posts, except the outer pair of gates, which were of greenheart, with ribs, intermediate posts, and wallings of pitch pine and Memel. The gates were 2 ft. 8 ins. thick at the heel and miter posts, and about 2 ft. 11 ins. thick at the center of the leaf, exclusive of the wallings. The back of the gates, when shut, formed a continuous arc of a circle from one hollow quoin to another, the radius of which was 50 ft. The ribs and intermediate posts of the upper gates were differently arranged to those of the middle and outer gates. The height of the dock wall was 40 ft. and the depth of the foundations below the dock floor varied from 2 ft. 6 ins. to 19 ft. The footings were of lime concrete, 22 ft. 6 ins. in width, and were carried up 3 ft. above the dock floor. From this level to the top the wall was built of rubble masonry, faced with dressed stone. Two failures of parts of the dock wall, caused by the wall slipping forward and sinking, were then described, and the remedial measures pursued, also the modifications introduced in the subsequent work. The earthwork chiefly consisted of clay. Upward of 1,750,000 cubic yards of material were shifted from the dock basin, lock, entrance channel, and foundations. Of this quantity, about 150,000 cubic yards were dredged from the entrance, and discharged from hopper barges at a shallow part of the Bristol Channel, about three miles from the works. The average cost of the excavations, including a portion of the pumping expenses, was about 1s. 6d. per cubic yard. The average price for rubble masonry was about 20s. per cubic yard. The Portland cement concrete consisted of 1 part of Portland cement, 3 parts of sand and gravel, and 5 of stone broken to a small size, and the whole mixed with large blocks of stone. The average price of this concrete was about 10s. per cubic yard. The lime concrete used for the foundations was mixed in the proportions of 6 to 1, viz., 1 part of lime, 2 parts of sand, 2 of ashes, 2 of broken stone, and cost about 10s. per cubic yard.

The second paper read was on—

## THE RIVER LAGAN AND HARBOR OF BELFAST.

By Mr. T. R. SALMOND, M. INST. C.E.

About two and a half centuries back the harbor of Belfast was but an insignificant creek of the Lagan, and was under no regular form of government. In 1785 the tide flowed up the river, a short distance above the town, but ebbed almost entirely out, leaving a narrow serpentine channel of fresh water, which flowed through extensive flat sands. The quays amounted to about 1,780 lineal feet, one-half of which could only be counted upon as suitable for vessels of large burden. In 1837 an Act was obtained, embracing the following works, which were ordered to be carried out:—1st. The construction of a new navigable channel through the slob ground, from the Dunbar Dock entrance to a point in the old channel course nearly opposite Thompson's Tower, thereby cutting away the first bend of the old channel next the town. Secondly, the purchase of all the existing docks and quays, which were owned by private individuals, and the widening and improving of the same. Thirdly, the formation of a second straight cutting or channel through "the Flats" in continuation of the first cut to the buoy of the Flats, where deep water would be secured. The first section of the new channel, from the Dunbar Dock to Thompson's Tower, was completed and opened for traffic in the year 1841; the cutting was about 3,000 feet long, 370 ft. broad, and 12 ft. deep at low water. The soil excavated from this work was used in the formation of the side embankments, and in making up the Queen's Island, a large portion of which has been utilized for shipbuilding purposes.



ENGLISH FANNING MILL.

required by the comparatively clean culture of the British.

The illustration shows a winnower, grain elevator, and weighing machine which has excited a good deal of attention.

The elevator is worked by a strap from the driving-wheel of the fan-mill, and raises the grain by cups as it passes from the mill, conducting it into a hopper sufficiently high to apply a bag at full length. Under the spout is a platform scale, to which a cord passes from a catch on the slide in the elevator spout, so that when the bag has its proper weight the descent of the platform disengages the catch, the slide falls, and the descent of grain is arrested. The hopper is suffi-

cient. The complete silting up of the old entrance of the Avon a few years ago, and the opening of the present Swash Way, was a striking example of mud settlement and accumulation. A temporary embankment, to exclude the tide during the construction of the works, was made by tipping silt excavated from the dock over the ground. A wooden truss was used to exclude the tide while the outer clay dam was being removed. It proved satisfactory; and the leakage from the tide was easily kept under by a small force pump. The mouth of the lock had a wing wall on each side, extending about 150 ft. beyond the roundheads, and diverging from a line parallel with, and 100 ft. distant from, the cen-

Between the years 1846 and 1849, the second cut of the new channel was executed. This cutting through "the Flats" between the Twin Islands, formed by the excavated material from the bed of the cut, was about 3,300 ft. long, the width at the top being about 450 ft., and the depth about 23 ft. at high water. A commencement was made in the year 1858 toward the regular deepening of the navigable channel. So great was the improvement effected by dredging between the years 1858 and 1861, that vessels of 22½ ft. draught were enabled to reach the quays at spring tides without lightening their burden. Dredging operations had been carried on from that date to the present time. The present course of the navigable channel at Belfast was straight for a distance of two miles northward from the Clarendon dock entrance, and it had an average depth below low water of about 12 ft. From the north end of the Twin Islands it was serpentine for about one mile toward the end of Garmoye, which had a depth of 20 ft. at low water. From this place it followed for another mile a straight course through Whitehouse roads, and curved again toward the northeast, across a bar about 4,000 ft. in length, with 11 ft. depth of water over it opposite the Oyster bank, into the open lough. The author gave a description of the shipping accommodation at present available at the port. Rather more than one-half of the quayage was of stonework, and the remainder of timber. On the County Down side of the harbor the subsoil was chiefly sand and stiff red clay; on the County Antrim side it was principally soft blue clay, for a depth of upward of 60 ft. before a firm stratum of sand or clay was reached. Between the years 1844 and 1847, when the construction of new quays was undertaken on both sides of the river northward of the Queen's Bridge, from the designs of Messrs. Walker and Burges, a timber wharf facing was adopted, be-

was not until 1823, when Messrs. Whidbey and Rennie suggested the construction of the west pier, that practical steps were taken to further enlarge and improve the harbor. The work was commenced in 1824. As the pier advanced seaward it became evident that the harbor was rapidly silting up. This was no doubt caused by the structure intercepting the shore currents, carrying with them sand and other matter in suspension. To counteract this deposition within the harbor, Mr. Rennie urged upon the trustees the importance of constructing the north pier, by which the current setting to the southward would be diverted. This suggestion was not adopted, and a few years later, when the west pier was well advanced, the shipmasters of the port memorialized the harbor trustees to prevent the further extension of the structure, as the difficulty of entering the harbor had already been greatly increased. In 1833, after Sir John Rennie had again advocated the importance of proceeding with the erection of the north pier, the work was commenced. In January, 1836, during a severe westerly gale, one vessel out of a large fleet, in entering the harbor, fouled the crane engaged in completing the jetty at the end of the north pier. In consequence of this mishap and of other accidents to the shipping, a public meeting was held, and a copy of the resolution passed was forwarded to Sir John Rennie, who, in reply, reminded the trustees that the pier head of the west pier had not yet been constructed as he had recommended. Subsequently the spur at the end of the north pier was removed, and the west pier was completed by building a bold pier head. The total cost of the works was about £160,000. On the completion of the west and north piers, the harbor of Whitehaven became one of the most commodious and convenient in the Channel, and many schemes were brought forward for obtaining wet dock accommodation at the port.

the harbor for traffic, an embankment was formed across the beach in the inner harbor, the seaward face of which was protected with stone pitching laid to a slope of 1½ to 1. Upon this embankment the permanent way was placed, connecting the north and south sides of the harbor. Slidings were also laid around the several quays in connection with the London and North Western and the Furness Railways. The crossing of the patent slip at the south end of the embankment was effected by a swing bridge; the weight of the bridge was 70 tons, and it could be opened or closed by one man at the turning gear. The old timber slip was demolished and a new one constructed further seaward; the extension of the waterway at Pow Beck, and the construction of a new quay across the end of the Custom House Dock, were also effected at the same time. The total cost of the construction of the wet dock, the north harbor extension, railways, and all other improvements was about £100,000.

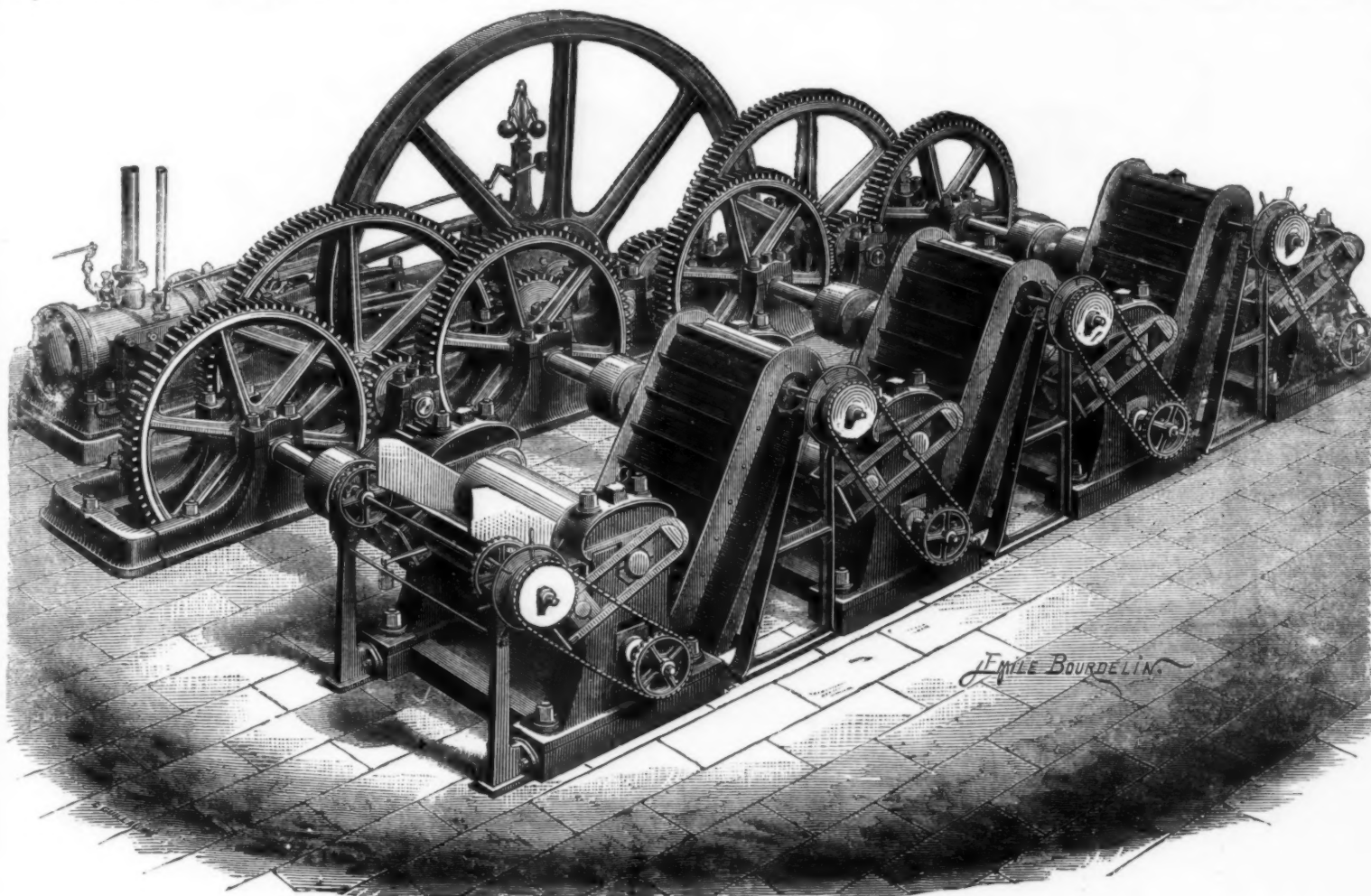
#### IMPROVEMENTS IN SUGAR CANE MILLS.

IMPORTANT as it is, in the manufacture of cane sugar, to extract as completely as possible the juice from the cane, the methods employed for this purpose for a long period have remained the same, evincing no sign of progress.

The changeable, sometimes very poor, results obtained by these methods have, however, shown their deficiencies clearly, and at present general attention is being attracted to better methods and improvements.

The General Council of Guadeloupe sufficiently demonstrated what it needed for colonial manufacture by offering a premium of \$20,000 to the inventor of a new perfected method or apparatus for expressing the juice.

This premium was, in 1876, awarded to Mr. Duchassaing.



IMPROVEMENTS IN SUGAR CANE MILLS.

ing tied back by iron rods and stay piles. The cost was comparatively small, being only about £13 12s. per lineal foot of wharf, which included "filling" to the extent of about 170 cubic yards to each lineal foot. In the year 1864 the dock accommodation was extended to provide a greater depth of water, and the new works were executed in stone. The depth of water for which provision was made was, on the County Down side, at Abercorn Basin, 10 ft. at average low water; and, on the County Antrim side, 15 ft. at low tide. The paper then described the construction of the walls and of the foundations of the Abercorn Basin, and of the Dufferin and Spencer Docks; also the settlement of the walls of the docks, consequent, in the author's opinion, on the weakness of the piling timber, the insufficient depth of footings, and the unsuitable material for filling in behind the walls. The general character of the most recent practice was exemplified by the Queen's Quay, which was constructed in 1877. The average rise of the tides at Belfast Harbor above Ordnance datum was 8 ft. 10 ins. at spring tides, and 7 ft. 4 ins. at neap tides. The highest spring tide on record was 17 ft. 3 ins. above Ordnance datum. The revenue of the port in 1786 was £1,558; that of 1876 was £99,533 6s. The tonnage in 1786 was 38,421, and in 1876 it reached 1,497,585 tons.

The third paper read was on—

#### THE WHITEHAVEN HARBOR AND DOCK WORKS.

By Mr. J. E. WILLIAMS, M. INST. C.E.

Whitehaven being situated on a bold and exposed coast, it was not surprising that many schemes had been brought forward for the improvement of the harbor. In 1768, Smeaton proposed its enlargement by the construction of a north pier and other works. Many other schemes followed, but it

But it was not until 1871, when the trustees of the town and harbor obtained the Whitehaven Dock and Railways Act, that practical steps were taken in the matter. The works were designed and carried out by Mr. Brunlees, V.P. Inst. C.E., the author being the resident engineer. In addition to the wet dock and railways, the works included the construction of new piers within the harbor, and the carrying out of other important improvements in connection with the port. The site of the dock was that originally proposed by Mr. Stiven, the surveyor to the trustees, and consisted of a portion of the north harbor and shipbuilding yard. This area was chiefly covered with sand, in some places of a treacherous and silty nature. Considerable difficulty was experienced in executing the work, owing to the north harbor having to be kept open for shipping. Progress was, therefore, tidal and intermittent in character. The dock was opened for traffic on the 22d of November, 1876, the tidal water having been excluded from the area of the dock works in the previous April. The wet dock had a water area of 4½ acres, and was surrounded by quay walls 40 ft. in height. The entrance was 50 ft. wide, and the depth of water was 21 ft. over the sill at spring tides. The old north wall was demolished, and a new pier, 50 ft. wide, was constructed, the north harbor admitting a much larger class of vessel. The seaward face of the new pier was built of ashlar, set block in course, and surmounted with a parapet wall. The walls against which the vessels lay were built of rubble and concrete, the face being hammer dressed, and laid in broken courses or sneaked, with a batter of 1 in 12. A portion of the foundation of the west quay walls was piled, and during construction a short length of the outer wall slightly settled immediately over the old channel of a land stream. This was arched over, and the wall carried up and surmounted by coping. In order to connect the north and south sides of

After treating the cane in the ordinary mill, he moistened the fibrous mass remaining with hot water, and again submitted it to compression in a mill consisting of three cylinders, similar to the one used for the first compression.

Another premium of \$20,000 is now offered to the inventor who, before the first of June, 1880, will find a new way by which the quantity of sugar obtained from 100 parts of cane will be raised to 14 parts, whether this end be attained by a better mode of expression or other means. The commission appointed to award the prize gives the following figures, from which we can easily see what has been possible previously and what is required now. The old method, as before 1876, gave a quantity of sugar, 9.40 per cent. of the cane used; result obtained by Mr. Duchassaing, 11.64 per cent., as at present, the increase by maceration and re-pression being 1.64 per cent.

It will be seen that the product was, compared with the results of the old method increased by Mr. Duchassaing's process in the proportion of 6 to 7, and that in order to obtain the premium in 1880, the inventor must be able to show an increase of 25 per cent. to the quantity realized by Mr. Duchassaing, taking it for granted that the cane will be as rich in 1880 as it was in 1876.

It has been thought to be profitable to cut up fine cane, as it is done with beets, in order to separate the juice more completely; but an examination of the nature of both plants will demonstrate the contrary. The beet presents a soft, pasty material to compression; the solid parts not being fibrous, and being homogeneously divided between the juice, offer little resistance. An ordinary press will, therefore, answer the purpose, and the apparatus used in beet sugar works on the Continent are, therefore, of no avail for cane.

Sugar cane is of a fibrous structure; the soft, cellular

parts, containing most of the juice, being located in the central portion, while the concentric layers of fibers become more woody, tough, and dry, the nearer they come to the epidermis. The great resistance offered by the fibrous cane to compression, when a certain pressure is reached, will always cause the retention of a certain quantity of juice; whether the stalks are previously cut or crushed would not make any difference.

In the cylinder mill, the cane is introduced and submitted to pressure in the condition as it is received from the field, the stalks forming a layer, in which they pull themselves along as they are caught and flattened down by the cylinders. The juice is mostly all separated before the cane passes between the cylinders, from which it issues in the shape of a fibrous band, flattened down and hardened considerably. This operation may be, after soaking the fibrous mass, the "bagasse," in water as often as necessary, in another pair or two of cylinders.

The advantage of the cylinder mill is easily conceived, as the entire process of manipulating the cane can be reduced to one continuous operation. Manual labor and its cost, which would be considerable in case the cane would have to be reduced to small pieces, is nearly altogether dispensed with, and the cylinder mills are in fact the only ones in use now.

The best three-cylinder mills cannot extract by one passage more than from 65 to 70 kilogr. of juice from 100 kilogr. of cane, the variation in quantity being due to the variable quality of the cane. In a moist, but otherwise favorable, season, and growing on humid soil, the cane will naturally contain more juice than after a dry season and when grown on dry soil. Thus, the ligneous parts of the cane remaining the same quantitatively, the juice gained therefrom varies between 60 and 70 per cent., and sometimes even more. Cane generally consists of from 85 to 87 per cent. of saccha-

and in their power. The products of the mills should be kept separate, to allow a better control.

It is a mill of this kind that we intend to describe. The mill of Mr. Rousselot is based on the same principle as the ordinary cylinder mill, but possesses some advantages which make it by far more desirable.

This mill, which is represented on the preceding page, is composed of four sets of cylinders, running in parallel direction, of the same length and at equal height. Each set consists of two pressure and one feed-cylinder. From one set to another the "bagasse" is carried by paddles attached to endless belts traveling over drums. The latter are provided with a regulator by which the rate of supply may be controlled. Between the mills hot water distributors are provided, by which the fibrous mass is thoroughly moistened. By the first set of cylinders the cane is thoroughly mashed and flattened out, as it is done in an ordinary mill, and the material is now automatically carried through the other three sets, being moistened with water. The results obtained by this operation are as follows:

|                       |                             |
|-----------------------|-----------------------------|
| Extraction by 1st set | .....64 per cent. of juice. |
| " " 2d "              | .....9 " "                  |
| " " 3d "              | .....6 " "                  |
| " " 4th "             | .....3 " "                  |

Being 83 per cent. in all.

Hereby 15 per cent. of water (of the entire quantity of juice obtained) was consumed. The quantity obtained by the first set may vary, according to the nature of the cane, but the consecutive compressions are pretty sure to express what was not expressed by the first set of cylinders. The less moisture, of course, as originally contained in the cane, the more water will be required. In this instance 3 per cent. of water was added between sets 1 and 2, 5 per cent. between

and in their power. The products of the mills should be kept separate, to allow a better control.

Altogether, this style of mill offers superior advantages. The cost of operation is low compared with the result, and the mill is easier regulated and controlled than any other. The motive power is completely utilized, and the quantitative results have so far not been equaled.—*Revue Industrielle*.

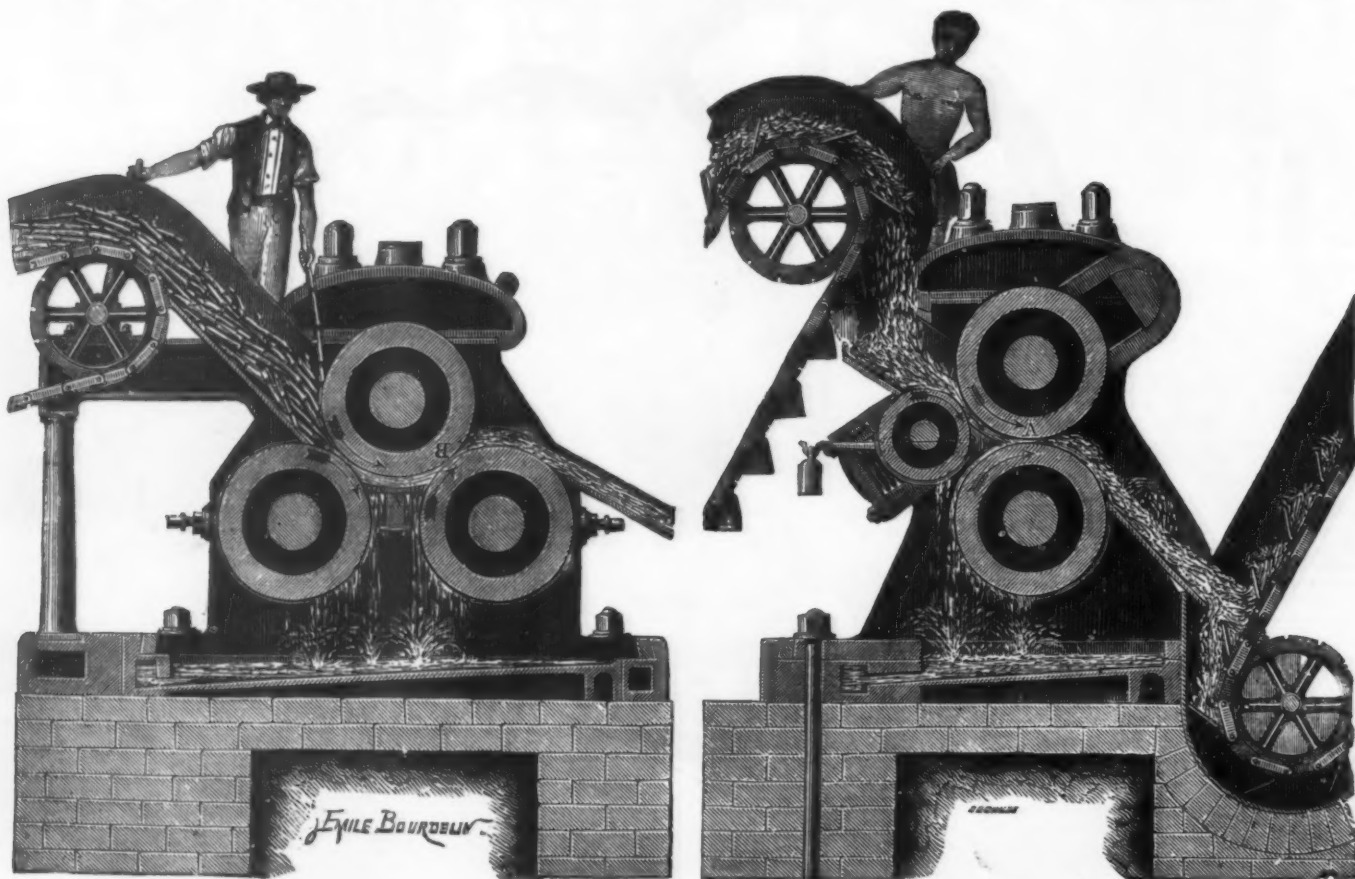
#### ARTIFICIAL DECORTICATION OF THE BARK OF TREES BY HEAT.

In 1873, already Mr. de Nomaïson proposed to apply steam to separate the bark from trees for tanning purposes. His apparatus, which was then very incomplete, has since been perfected, and at the Paris Exhibition in 1878, Messrs. Mouchet Bros., who have acquired the sole right to manufacture the same, received a gold medal for it.

At present, the time of sapping, during the month of May, is the only period in which the bark may be successfully harvested. The success depends greatly on the weather, as a sudden frost or even a fog is sufficient to make decortication impossible. It is generally admitted that, according to the old method, 25 per cent. of the harvest is actually lost for these reasons. Another source of loss is the exhaustion of the stumps, the cutting taking place just when vegetation displays the utmost activity.

This problem Mr. Nomaïson has solved in a happy manner. It consists in treating the woods with dry, superheated steam.

The apparatus is composed of a tubular, vertical, cylindrical boiler, with interior heating surface. A feeding reservoir is arranged so that the water is heated by the furnace gases before entering the generator. The latter surrounds



IMPROVEMENTS IN SUGAR CANE MILLS.

rine juice and from 13 to 15 per cent. of solid matter. By the present mode of extraction, as it is easily seen, only 75 per cent. of the entire liquid portion is really extracted, while the remaining 25 per cent. is lost to manufacture.

By continued observations and experiments we have succeeded to construct the cylinders in such dimensions and work them at such an initial velocity of rotation, thereby exercising such a pressure that at present we have reached the maximum quantity of juice obtainable by one single compression from a given quantity of cane, and it is clear that, no matter how powerful an apparatus we may employ, we shall always only be able to produce incomplete exhaustion. Of all the means employed to overcome this difficulty, maceration (soaking), or moistening the compressed fibrous mass with hot water, submitting the same again to pressure, and repeating this several times, has been found to give the best results. Mr. Wm. Russell introduced this first, in 1875, at the Léonora plantation; he employs three-cylinder mills of Rousselot's system, constructed by Fawcett, Preston & Co., of Liverpool. These mills are to-day better known and more generally introduced than any other, and if they do not yet completely separate the juice, they give at least the best satisfaction as regards the amount of labor performed and facility of operation.

In the three-cylinder mill the cane is only submitted to a moderate pressure between the first and second cylinder; it is thereby prepared for the stronger compression exerted between the first and the third cylinder. In a combination of two of these mills, operating successively on the same lot of cane, the second mill furnishes from 7 to 12 per cent. of juice. If 65 per cent. has been obtained through the first mill, 9 per cent. seems to be the medium product of the second mill in good, juicy cane, without maceration after the first compression. In a system of three or four mills, the cane must be moistened with hot water, while passing from one to the other mill, the quantity of water necessary decreasing proportionate to the increase in the number of mills

sets 2 and 3, and 7 per cent. between sets 3 and 4. For 200,000 kilogr. of cane, furnishing 164,000 liters of juice, 24,000 liters of water would hence be required. This may be considered as a minimum quantity of water.

The cylinders in this mill are 1.50 meters long; the mill can extract within one hour the juice of 16,000 kilogr., the same as an ordinary three-cylinder mill of the same dimensions and running at the same velocity.

The whole is moved by a system of toothed wheels, the power being transmitted to the lower cylinders. The motive power is derived from a steam engine of 80 horse power, being twice the power required by a simple three-cylinder mill.

The two cuts above represent the difference in the mechanism and mode of compression in the ordinary cylinder mill and the Rousselot mill. In the former the material is immediately submitted to high pressure between cylinder 1 and 2, and must be raised from A to B, by which much power is lost; the conducting channel for the cane is much inclined, and takes up much room. In the latter the feeding and conducting belts are less inclined, are of smaller dimensions, and take up much less room. The smaller cylinder only serves to fit and prepare the cane for pressure.

Mr. Rousselot can, of course, furnish ordinary mills with one or more sets of his construction. By attaching two sets to a common mill, producing 65 per cent. of juice from good cane, 15 per cent. more of juice will be obtained. For a mill altered in this way, so as to consist of two sets of cylinders of 1.50 metres in length, a 40 horse-power engine will be necessary.

An important feature has some years ago already been introduced in sugar cane mills by Mr. Rousselot. This consists of making the mills partially of cast iron, the latter being used for the immovable parts of the structure having to bear the principal weight, and partially of malleable iron for the movable parts, especially those having to overcome resistance of variable energy, just as it depends on the quan-

the fire entirely. The boiler tubes come also in contact with the heating gases on their entire surface, heating and drying the steam, which arrives in the upper part, and issues at a temperature of 170° C. The boiler is supplied with a water indicator, and is fed by means of a pump, which simultaneously takes the warm water from the upper part of the reservoir and supplies cold water below.

The steam is used up as rapidly as produced; hence the pressure and danger of explosion is very small indeed. The machine is provided with two pivots, by which it may be suspended on a sort of truck and moved from one part of the forest to the other. The simplicity, light weight, and facility of transportation of the apparatus offer superior advantages.

The wood or logs to be peeled are placed in wooden cylinders or tanks, of which there are generally four, arranged symmetrically around the boiler. The steam enters at their lower part through a pipe connecting with the boiler and supplied with a stop cock to regulate the admission of steam. The tanks may vary in dimensions to suit the length or thickness of the logs, the length usually varying between 1.25 and 3 or 4 meters. The capacity should, however, not exceed 1.25 cubic meters, so that the diameter must decrease when the length is increased. The tanks rest on small wooden horses, and are slightly inclined toward the outer extremity, where a hole is provided through which the juice of the wood and the vapor condensed can run off.

When the steam is for the first time introduced into the tanks the wood work absorbs a great deal, so that about two hours are required to complete an operation. The second time this loss of steam and heat is not incurred, so that the operation is finished in 1½ hours, or even in less time. Much is dependent on the temperature of the logs when introduced, and also on the period that has elapsed since the logs have been cut. Very thick logs of course will take up more time than thin ones. From time to time a log may be taken out to determine whether the operation is finished.

This is generally the case when the juice commences to flow from the wood and the steam escapes through the joints. The logs are now taken out of one tank first, when they can easily be stripped of their bark in smooth whole pieces. Then the tank is filled again and another tank emptied. Thus a continuous process is established, by which no time can be lost, as when tank No. 4 has been emptied and refilled, the second charge in tank No. 1 is ready for peeling again. 1,400 kilog. of good bark can be obtained by one apparatus and six men in one day.

The bark thus obtained is quite as good as that obtained by the old method. It is evident that vast quantities of wood, which had so far been used with the bark for charcoal, hoppers, beanstalks, and other purposes, can now easily be deprived of their bark first, whereby much can be saved. The wood treated thus is hardened by the steam, and is fit for railroad constructions, etc., without being prepared in any other way.

Finally, many trees, containing not enough tannin to pay sufficiently for the trouble heretofore incurred by barking, can now be made serviceable for tanning purposes. We would mention the birch tree (the bark of which is used to some extent for making Russian leather), the linden tree (the bark of which may, deprived of its tannin or as it is, be used for making matting and cords as strong as those made of hemp and linen), the chestnut, the fir, and the cedar, the

the universal introduction of this apparatus, as it is to their pecuniary advantage. The fact that the harvest falls in winter time saves half a season's growth to the trees, the damage done in spring by the necessary employment of cattle or horses and carts, as well as by the exhaustion of the trunks when the bark is cut at sapping time, is not inconsiderable, but completely obviated here. If, in some countries, the oak forests become depopulated and thinned out, we can only find too good a reason for it in the irrational manner in which the exploitation of forests for tanning and other purposes has so far been conducted.

This apparatus at least does away with one difficulty so far encountered, and it will probably, after being introduced to the public at large, by the Exhibition of 1878, soon come into universal use.—*Revue Industrielle*.

#### ARTESIAN WELLS.

We will first give some account of the most recent borings in San Francisco, where a large number of artesian wells have been sunk, together with the tools there employed.

the citizens of Winnemucca will avail themselves of the Desert Land Act. Arizona has caught the fever. Montana is just getting it, and her press is beginning exhortation to artesian efforts. And so it goes. Thus it happens that every one is alert to any item or article connected with the subject of artesian wells. People are asking how to bore wells, how much it will cost, how much water they can get, and what kind of water if they get it. And on the track of these practical water seekers there hovers a troop of scientific scavengers, who with intense curiosity bore the borers with: How deep did you go? What strata did you pass through? Did you strike any tree? Give me a piece of the mud? It is with a view to satisfying in some imperfect measure all of these inquiries that this series of articles is undertaken. And imperfect though it must be, it cannot fail to prove of some little entertainment.

For reason we will follow a very unscientific course. We will take up first the wells of San Francisco.

#### UNDERGROUND SAN FRANCISCO.

There have, perhaps, been bored in San Francisco upward of 500 artesian wells. We know of only about 90. Of some of these we have none of the data, and of very few are



APPARATUS FOR THE SEPARATION OF BARK FROM TREES.

wood of which is now largely used for preparing paper-pulp.

An official commission, consisting of conservators and inspectors of forests, wood merchants, and tanners, has lately been appointed to inquire into the merits of this apparatus. The experiments took place in the government forest at Viroflay, and in consequence the state has purchased an apparatus for the Board of General Directors of Forests.

The Society of Agriculturists of France have awarded to the Mouchelet Bros. their great prize of 1,000 francs.

The administration of State Forests has officially recognized the advantages of the apparatus in its official report on file in the Trocadero. Mr. Riche, chemical expert to the Department of Agriculture, has made a comparative analysis of two samples of bark, derived from the same forest, from healthy trees, one by Nomaison's process, in winter, the other taken from a tree at sapping time, with the following result:

Percentage of Tannin. In bark treated by Nomaison's method, 6.73 per cent. ordinary method, 5.48 per cent.

Difference in favor of steam process, 1.24 per cent.

This shows clearly that it must be in the interest of owners of forests and tanners to facilitate as much as possible

over the entire coast. We believe it started with San Francisco trying to reduce her expenses. It has spread throughout California. Some citizens of Winnemucca, Nevada, have clubbed together to pay the expenses of a trial well, which, if successful, will, to use the expression which is epidemic with the artesian fever and spreads wherever it does, "make the desert blossom as the rose," whereupon

tered the figure again to 93, which, on examining the profiles, turns out to be the most probable depth. Where depth is so freely dealt with it might be expected that strata passed through would be carelessly recorded. That this is the case will appear when we present our data, which we will give in full just as we got them rather than attempt at present to reduce them to system.

Our data have been furnished us principally by Mr. Patrick Delaney, of 764 1/2 Howard street, San Francisco. Mr. Delaney is a pioneer well-borer and has had great experience with San Francisco artesian wells. Very complete and intelligible information has been gained from Messrs. Stevens & Wilder, of Folsom and Eleventh streets, San Francisco. We shall have occasion to speak further of our informants.

In several of the wells wood and leaves have been struck. In others gold has been met with, both in quartz, gravel, and in black sand, though hardly in sufficient quantities to warrant the fear that deep placer mining at San Francisco will detract in any great measure from the ocean beach excitement. Some of the wells have been affected by the tides. Some wells close to each other have affected each other's supply. Others, grouped even more nearly together, have seemed to be entirely independent as to water resource. Brackish water has been found in some wells; in some very hard water; in others good soft water. These and other exceedingly interesting and instructive facts will appear as we study the wells. Fig. 1 is a map of the principal part of San Francisco, showing the old land line, and in a general way the locations of about 70 wells. Choosing lines passing through or near the greatest number of widely-separated wells, and forming as nearly as possible a rectangle, as shown on the map, we have drawn profiles of the city on these lines showing the depths of the wells. These profiles show a degree of conformity in the water strata to the surface, which would go to show a less broken condition of strata than is indicated by the outcroppings on the hills and by the well-borers' expression, that the "veins of water are like the veins in a man's arm;" however, when the imperfections of the data are seen, and other things are considered, it will appear that there is little to justify joining the bottoms of the wells, as has been done in the profile maps, Figs. 1 and 3. On the profiles the horizontal scale is to the vertical as 1-50:1. Hence the great distortion.

Now for the wells:

No. 1. 140 feet deep. No further data.

No. 2. 13-inch well; 194 feet; struck rock at 160 feet; got through it; quit without rock.

No. 3. 184 feet; sand down to 50 feet. Got no water until went 175 feet; got into sand and gravel, and then water came up to within 20 feet of the top.

No. 4. 89 feet. Filling, 40 feet; black mud, 10; sand and clay, 9; stiff yellow clay, 12; water, sand, and gravel, 12; hard clay, 3; bed rock, 2.

No. 5. 201 feet. Blue clay, 40; then hard, black sand without water; at 108 feet struck black rock.

Less than a block from No. 5 is another well, the data of which are: 133 feet deep to the rock; yellow clay, 80 feet.

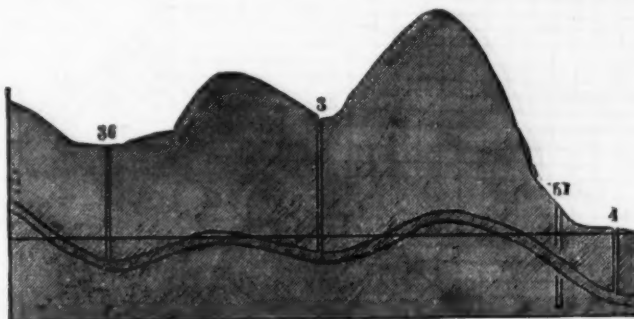


FIG. 1.—PROFILE FROM EDDY AND DEVISADERO TO JACKSON AND SANSOME.

In the concluding papers we will give particulars of artesian wells in other parts of the country, the tools, costs, etc. For the following particulars of the California wells we are indebted to the *Mining and Scientific Press*:

No one need be told that the subject of artesian wells is at present an interesting one. An artesian fever is spreading

there clear and full accounts either of depths or of strata passed through. As an illustration of the difficulty met with in finding out the real depths of the wells, it may be stated that the well on the Plaza, No. 51, on Figs. 1 and 2, was reported first at 400 feet. A well-borer finally changed this to the neighborhood of 230; still another well-borer at

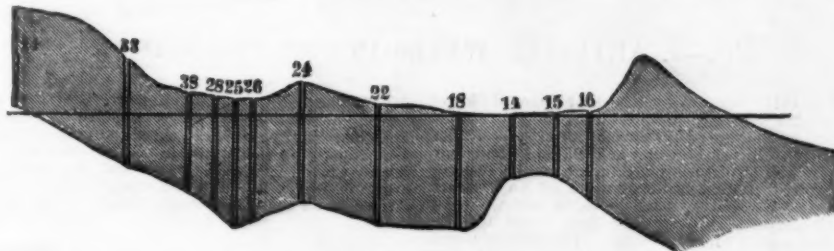
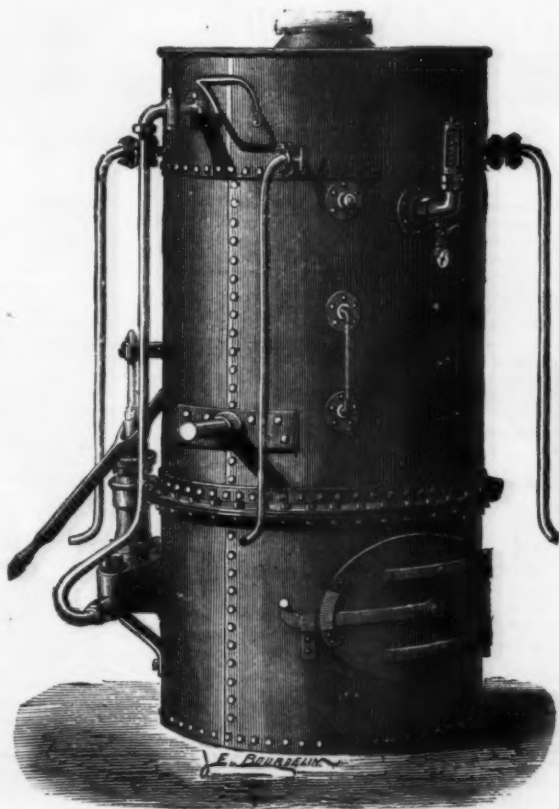


FIG. 3.—PROFILE FROM NOE AND MARKET TO FIRST AND BRANNAN.



APPARATUS FOR THE SEPARATION OF BARK FROM TREES.

No. 6. 181½ feet; 40 feet of bay mud, 15 of black sand, then got into yellow clay and gravel, then hard dry sand without water, then into yellow clay and small rock, then

plies quite a number of dwellings with clear, sweet, cold water. Sand, 28; blue clay, 8; cement and clay mixed, 6; light gray sand, 4; streaks of sand and clay, 7; solid blue

This would indicate defects in the notes, great tilting of strata, or else furnishes foundation for the underground river theory.

No. 23. 140 feet; quicksand, 60 feet.

No. 24. Bore, 7 inches; depth, 144 feet. The water is pure, cold, and sweet, rises within 3 feet of the surface, and cannot be lowered by pumping. It supplies fifteen families and a Chinese wash-house, besides water for sprinkling in front of the premises. Sand, 24 feet; yellow clay, 16 feet; soft sandstone, 6 feet; gravel and sand, 18 feet.

This neighborhood is peculiarly interesting. Less than 200 feet northeast of No. 24 is a flowing well, 150 feet deep. About 30 feet east of this last-named is another, 240 feet deep, which gives 80,000 gallons per day, supplying a tannery. About 30 feet east again of this one is still another, giving, it is said, about the same supply, but only 160 feet deep. Southwest of this, about 100 feet, is yet another, 150 feet deep, the water rising to the surface and refusing to be lowered. About 250 feet north of Eleventh street, on Folsom, is another, 155 feet deep. None of these wells affect the others. At Ninth and Folsom, about two blocks north of the last-named well, is a well 176 feet deep. In boring this the following were passed: Sand, 40 feet; clay, 40 feet; quicksand, 20 feet; clay and cement in streaks; at 160 feet, sandstone, gravel, and black sand were passed into; at the bottom, gold-bearing quartz was found, assaying, we believe, \$200 to the ton.

(To be continued.)

#### THE NIAGARA FALLS MILL.

For the tourist, no natural wonder has so many associations, or recalls to the mind such scenes of sublimity, as Niagara Falls. As it is the grandest of earth's cataracts, so is it incomparably the greatest water power in the world; and doubtless it was essentially the same eye to business that prompted one American to suggest fencing it in and charging an admission fee, and another to undertake the utilization of its immense power for the purposes of industry. One smiles at the proposition to convert the most wonderful of Nature's scenes into a money-making show; but it is a part of our American creed that work is worship; and the idea of employing Niagara's mighty force to turn the wheels of industry does not, to an American, appear at all incongruous with the surrounding grandeur of the place.

The vast structure which forms the subject of our engraving and the present article, is but the realization of a scheme which is as old or older than the present generation. Years ago, General Porter secured a grant of land above and below the falls, and associated with himself several other gentlemen, who were quite as enthusiastic as himself over the project of building a canal around the Falls. Hundreds of thousands of dollars were expended upon it, and Boards of Trade all over the country were loud in their demands for a ship canal. Congress was appealed to for an appropriation, the scheme being championed by Hon. Isaac N. Arnold, of Chicago. The influence of Buffalo in Congress defeated the project, and the owners of the land grant and canal grew discouraged, as well they might, when it is remembered that in some places it was necessary to blast twenty or thirty feet of rock in order to get ten feet of water. Meanwhile, the taxes were unpaid from year to year, and the mortgages were heaped up. Finally, the partially completed canal and 100 acres of water front on Niagara River below the falls were sold for \$71,000 to foreclose a mortgage.



FIG.—2. ARTESIAN WELLS IN SAN FRANCISCO.

on the rock at 181½ feet. We believe that this well did not get good artesian water, but after reaching the above depth was cemented up so as to supply surface water.

No. 7. 84 feet. Struck blue clay at that depth and quit. No water. A well 160 feet deep had been bored here before. The unnumbered well immediately north of No. 7 struck blue clay and no water at the same depth, 84 feet.

No. 8. 103 feet deep. No further data except that the well furnished a good supply of water. This well furnished black sand, at first thought to be gold-bearing, and some little placer mining was done at the dump. The most interesting fact connected with it is that while it struck water, well No. 37, not 300 feet away, went down 212 feet in vain.

No. 9. 84 feet deep. Sand, 30; then clay. 10. The borer's comment is, "I will defy the world for better water."

No. 10. 103 feet. Clay, 40; hard sand, 30; then hard sand to the water. The unnumbered well across the street is only 116 feet deep, flowing. At 100 feet struck white, hard sand.

No. 11. This well, between No. 10 and No. 12, went 174 feet. Sand and clay, 90; then water all the way down; at 111 feet struck a flow that came 8 feet over the surface.

No. 12. Two wells, at about equal distances west and east respectively of this number, give the following data: West, 201 feet to the rock, quicksand down to 90 feet; blue clay from that down. East, 110 feet deep; 30 feet of sand to the water. This well yielded to the pump 75,000 gallons per day. When this amount was pumped out a well about one block to the east ceased flowing except at night, when the pumping at the former was stopped.

No. 13. 84 feet deep; sand, 30; from that down flowing well; water raised 6 feet above the surface. Across the street from this another well gave the same data. On the same block east there were two more flowing wells.

No. 14. 74 feet; blue mud, 40; flowing well. A short distance east of No. 14 a well flowing 8 feet over the surface gave the following data: Depth, 140 feet; filling, 10; blue mud, 40.

No. 15. 75 feet; blue mud, 75; flowed when bored. Another well on the same block went 140 feet, the first 40 being blue mud.

No. 16. 112 feet; good water. The unnumbered well beyond the old land line, on Third street, was bored originally 175 feet. Water then raised to the surface, but only 600 gallons per day. This supply being insufficient, a diamond drill was put on and the well bored to a depth of 675 feet, but no more water was obtained. At well No. 39 about the same thing was done. The circumstances were, we believe, something as follows: Water was obtained at the ordinary depth for this neighborhood, when an injudicious use of giant powder injured the well and necessitated the use of the diamond drill. The well went to a depth of 500 feet, and, we think, found water.

No. 17. 140 feet; sand, 50 feet; at 130 feet struck a bed of acorns and leaves.

No. 18. 142 feet; blue clay, 40 feet; flowing well.

No. 19. 130 feet; quicksand, 40; blue clay, 35; water from that down; flowing well. About half a block northeast of this another well gives: Depth, 180 feet; quicksand, 20; blue clay, 20; rock at 150 feet. A block southwest of No. 19 is another well, No. 41, 120 feet deep, with water within 8 feet of the surface. Well No. 50, in the same neighborhood, is 124 feet deep.

No. 21. 78 feet deep; flowing when bored. A curious fact is noticeable here. Well No. 23 is only one block from 21, yet its data, which are most complete, give no account of water above a depth of 133 feet.

No. 22. Bore, 8 inches; depth, 144 feet. This well sup-

plies quite a number of dwellings with clear, sweet, cold water. Sand, 28; blue clay, 8; cement and clay mixed, 6; light gray sand, 4; streaks of sand and clay, 7; solid blue



THE NIAGARA FALLS MILL.

The purchase was made in the name of Messrs. Schoellkopf & Cheesbrough, the latter being the mortgagee and the former the senior partner in the firm of Messrs. Schoellkopf & Mathews, the well-known milling firm of Buffalo. These gentlemen at once determined to erect upon the canal a flouring mill, whose size and completeness should be worthy of the place and its associations.

But before we venture to describe the monster mill, which was the result of this determination, let us glance at the arrangements for utilizing the water power, which have cost, to the various owners, at least a million dollars. The mill and elevator are situated on the brink of that immense cañon, nine miles long, which Niagara has worn out of the solid rock in the lapse of centuries, and whose depth at the mill is 210 feet. The location is something over a half mile from the falls, and at the end of that expensive canal, though only a mile long, which taps Niagara River above the Rapids and Falls. The head race is about 300 feet long, the sides being built of dressed stone laid in cement, and is arched the greater part of its length. There are two head gates, one at the pond and the other at the bulk head. This last is made of cut stone, and is 18 feet square, and deep enough to hold fifteen feet of water. Both race way and bulk head were made deep enough to stand over two feet of ice without drawing upon the head. From the bulk head the water is brought to the water wheels, a distance of 38 feet, in a tube made of boiler iron, and 10 feet in diameter, the water leaving the tube at right angles with the head race. The pit in which the water wheels are placed was blasted out of solid rock on the edge of the precipice. It is 50 feet deep, 34 feet wide, and extends back 30 feet. The pit under the larger wheel is 7 feet deep and 9 feet wide, and that under the smaller wheel is 7 feet deep and 6 feet wide. The penstocks of both wheels are placed on iron girders, supported by heavy iron columns. The motive power is furnished by two American turbines, made by Messrs. Stout, Mills & Temple, of Dayton, Ohio, who also supplied the penstocks. The supply pipe, and shafting, gears, and bridgetrees for carrying the gears, were designed and furnished by Messrs. E. P. Allis & Co., of Milwaukee. The larger turbine is 54 inches in diameter, and is placed in an iron penstock. Under a head of 52 feet it gives 660 horse power, which is said to be the greatest power furnished by any wheel west of Lowell, and the greatest power supplied to any flour mill in the world by a single wheel. It is calculated that the power it supplies would drive a forty run new process mill, with all the necessary machinery. The shaft for the wheel is of steel, and is 53 feet long and 5 inches in diameter. This wheel drives the mill proper and all its machinery except the flour packers. These and the cleaning machinery, together with the elevator machinery, are driven by a 30 inch American turbine in an iron penstock, which, under the same head as the larger wheel, develops about 300 horse power. The shaft for this wheel is also of steel, 3½ inches in diameter, and of the same length as the shaft from the larger wheel. Both wheels are regulated by Champion water wheel governors. The upright shafts of both wheels are carried on wrought iron "I" beams, 36 feet in length, and fastened at either end to heavy cast brackets, which are firmly bolted to the sides of the pit. The driving wheels and line shaft are carried in cast iron bridge trees, which are supported by three wrought iron "I" beams, placed across the top of the pit. It will be seen that everything except the head gates connected with the carrying and utilizing of the power is built of iron or stone. We have thus enlarged upon this branch of the subject, not only because it is one of the most interesting points in connection with the mill, but also because it is the most expensive application of water power in the world.

The present edifice is but the beginning of a series of manufacturing establishments which will make Niagara famous as an industrial center. The canal, where the power becomes most conveniently serviceable, is only about two hundred feet from the river, and there is room right there for thirty mills, each with a hundred feet front, and each driven by practically unlimited water power. Moreover, this power may be used all the time. In winter the Rapids cause a kind of granulated ice, which clogs the wheels of the paper mill at Goat Island. This is not the case with the power supplied to the Niagara Falls Mill. Ice may form in the canal two or three feet thick, and yet an ample supply of water will run under the ice as long as Lake Erie remains where it is.

Let us now glance at the mill building and elevator, which are accurately represented in our engraving, but the imposing appearance of which can only be appreciated by actually seeing it and taking in the ensemble of the situation. The material used in construction was Niagara limestone, quarried from the basement and wheel pit, and the walls are four and a half feet thick. The main building is 130 feet long, 65 feet wide, and 108 feet high. There are six stories, of which the first, third, and fifth are 16 feet high; the second, fourth, and attic, 14 feet high, and the sixth story, 10 feet high. The roof covering the structure is iron. The mill is planned for 32 run of 4½ foot burrs, and has at present 22 run in operation. The burrs stand in two lines of eleven pairs each, the main line shaft running between these lines. The shaft is supported on an adjustable cast iron stand. The burrs are driven by quarter twist belts, and are placed on solid iron hursts. Messrs. Jno. T. Noye & Son, of Buffalo, furnished 20 run of the burrs. On the stone floor there are six Eureka flour packers and a very nicely furnished office.

The third floor contains 6 sets of Wegmann's porcelain rollers, 4 sets of Downton's chilled iron rollers, the wheat garners, the flour bins over the packers, the bran bins, and three two reeled bolting chests for dusting middlings. The fourth and fifth floors contain the bolting chests, in which there are 40 reels, 4 large sized United States bran dusters, 14 Geo. T. Smith purifiers, and the exhaust fans from the stones. On the sixth floor are the gearings to drive the bolts, heads of elevators, aspirators, first dust room from purifiers, etc. The attic contains two reels, machinery to drive the passenger elevator that runs from the top to the bottom of the mill, dust rooms, etc.

The elevator and cleaning rooms connected with the mill are 132 feet long, 40 feet wide, and have a total height of 88 feet. The elevator is divided into 20 bins, each holding 6,500 bushels, and therefore has a capacity of 130,000 bushels, although more can be crowded into it. The basement is built of stone and the rest of the building of "Lamire" walls, covered with corrugated iron. The cleaning rooms are in the elevator building and next to the mill. The machinery is arranged in sets of four machines on each floor, and consists of two large Eureka brush machines, 4 Trimmer smutters, 4 Richmond separators, a Barnard & Leas separator, 2 Cockle separators, and a large suction fan. Between the mill and elevator is an archway 30 feet wide, with two railroad tracks and a wagon track running

through it. These tracks are provided with a transfer table, so that cars may be changed from one track to another, and switched without employing an engine, as the transfer table connects with the power that drives the elevator. Under the table there is a large track scale. The space above the tracks is used for storing bran and offal, which may be drawn directly into the cars.

Where everything is on so vast a scale, mere description is inadequate to convey a just impression of the magnitude and workings of the mill. In addition to what has already been said, it only remains to be added that the mill and its accompaniments were constructed with a view to their efficiency and not to their cost to the proprietors. The mill contains every appliance of a first-class modern new process mill, and has a capacity of about 1,000 barrels per day, and employs about 25 men. In connection with the mill, but in separate buildings, are the cooper shops and warerooms. The barrels are made under contract with Messrs. Esser & Sommer, who employ from 80 to 35 men. Machinery is used for making the barrels, the power being transmitted to the cooper shop from the main building by wire rope.

Messrs. E. P. Allis & Co., of Milwaukee, Wis., were the contractors for furnishing and putting up the machinery of the elevator and mill, and to them is due the credit of having completed one of the best mills not only in this country, but in the world. They took the contract last January, by the terms of which the mill was to be in running order by September of the present year. In that comparatively short space of time, however, the work was all done, and a complete mill, of which they may be proud, handed over to the proprietors by the specified time. The plans were all made by Mr. William D. Gray, superintending millwright for Messrs. E. P. Allis & Co., and the work executed under his supervision, assisted by Mr. Odell.

Messrs. Schoellkopf & Mathews, the owners of the Niagara Falls Mill, are known as being among the most substantial millers and business men of Western New York. The present firm was formed May 1, 1875, and in addition to their new mill they operate the Frontier Mills, at Buffalo, whose capacity is 325 barrels per day, and the North Buffalo Mills, the capacity of which is 225 barrels per day. All of their mills are operated on the new process, using only Wisconsin and Minnesota spring wheat for their patent flour. The principal brands are "Mathews' Patent," "Brown's Patent," "Surprise," and "Noble," all patent flours. Quite a large proportion of the products of these mills is exported to Europe. Messrs. Schoellkopf & Mathews' head miller, Mr. John Smith, has general supervision of the work at all these mills, and is assisted by Mr. Arthur Schoellkopf, son of the senior member of the firm.

As to the personnel of the firm, Mr. J. F. Schoellkopf, the senior partner, has been engaged in the tanning business in Buffalo for the past 35 years, and now owns and operates three large tanneries. He is also president of the Citizens' Gas Co., of Buffalo, and is largely interested in other enterprises, besides being half owner in the hydraulic canal property at Niagara Falls. He has been indirectly interested in flour mills for some years and is about 60 years old. Mr. Geo. B. Mathews is the manager of the business, and although only 30 years old, has been engaged in milling thirteen years. Both gentlemen are well known and highly esteemed in business circles. It was the growth of their business that prompted the erection of the new mill, and in view of this fact and their prosperous business experience in the past, a prophecy of the future of the Niagara Falls Mill is rendered superfluous.—*American Miller.*

#### TELEPHONE IMPROVEMENTS.

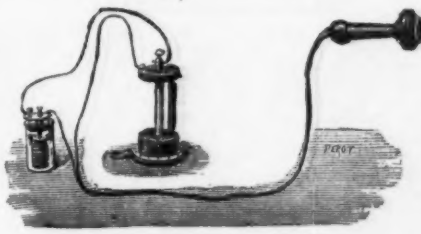
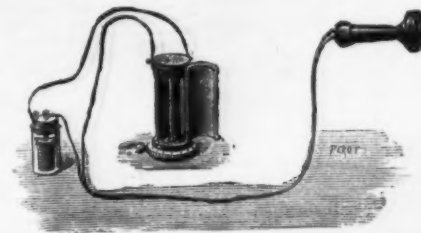
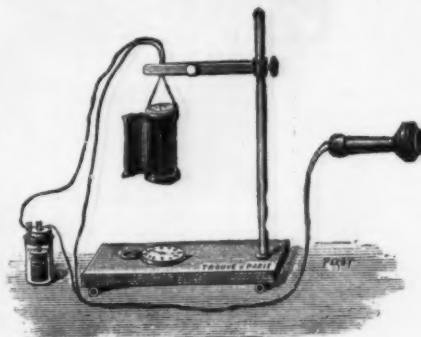
The engraving, Fig. 1, represents a telephone with the "inflexible" diaphragm. It consists essentially of a piece of prepared carbon, C, inserted in a ring of hard rubber or ebonite in such a manner that one surface is brought into contact with the very broad-headed metal screw forming part of the metallic frame of the apparatus. The other side of the carbon is covered with a circular piece of platinum foil, P, connected to a binding post insulated from the frame, and forming the other connection for putting the instrument into a circuit. Over the platinum foil, to which it is cemented, is a glass disk, G, carrying a knob of aluminum, against which the diaphragm presses slightly. When the instrument is spoken into, the variations of pressure are communicated to the carbon, and the electric undulations are accordingly set up in the now well-known man-

generated in them when the diaphragms are made to vibrate mutually strengthen each other, and thus contribute to the effectiveness of the apparatus. With a carbon telephone (Fig. 1) as a transmitter, and a single crown Phelps telephone (half of that shown in Fig. 2), as a receiver, very excellent results have been produced.

#### TROUVE'S MICRO-TELEPHONE.

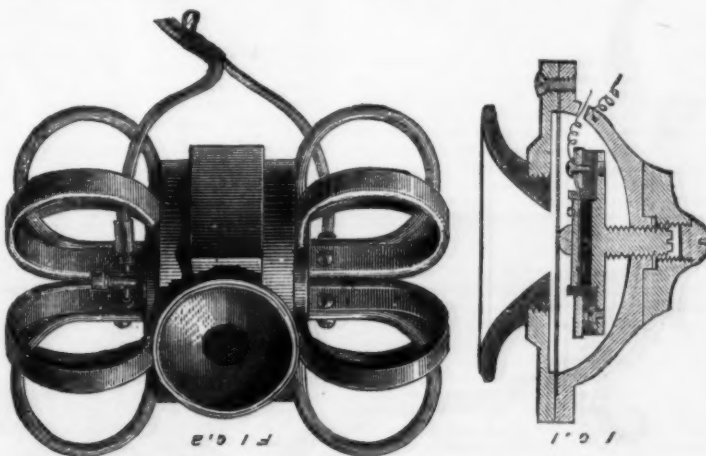
A new form of telephone, possessing also the intensifying power of the microphone, is described in *Les Mondes*.

The apparatus of Mr. Trouvé has the form of a small dark lantern, the candle of which has been replaced by a carbon pencil, connected at its ends with the wires of the electric circuit. When placed in a moderate-sized room, every sound, such as the ticking of a watch placed on top of the instrument, steps of persons, the human voice and the sounds of instruments may be distinctly heard at a considerable distance. Musical sounds are even transmitted when issued at a distance of 200 feet from the instrument. The sound is, of course, as in other instruments of the kind, transmitted by the modifications of the current by the action of the vibrations on the carbon pencil.



TROUVE'S MICRO-TELEPHONE.

In this instrument the intensity of the sound is based on the property of the cylinder surrounding the carbon to act both as a sounding board and a reflector of sound, by which all the vibrations are concentrated on the carbon. Arranged as in Fig. 1, all sorts of sound are transmitted equally distinct, but when suspended by strings, as indicated in Fig. 2, sounds, like the ticking of a watch and other unmusical sounds, are hardly perceptible, while the human voice and



THE DOUBLE CROWN TELEPHONE.

ner. But the vibrating diaphragm, it will be seen, still exists.

In Fig. 2 is seen the double crown telephone of Mr. Phelps. It contains two diaphragms, and in shape somewhat resembles a double crown, as shown in the figure. Twelve permanent magnets bent into a circular form are used in place of the single magnet employed in other magneto-telephones. Six of these on each side of the instrument have their like poles joined to one of the cores which carry the helices, and radiate from it in as many different directions. The opposite poles are joined to the periphery of the diaphragms on the corresponding side of the instrument, while the helices are so connected that the currents

other melodious sounds are transmitted with admirable intensity and clearness.

It has been observed that the intensity of transmission decreases in the measure, as the position of the carbon pencil approaches more and more to the horizontal line, being most powerful when perfectly perpendicular, and weakest when altogether in a horizontal position.

On the 20th Sept. the tar works of H. Vale, near Hamburg, exploded. The roof of the retort house was shattered, and the boiler for preparing the tar was burst.—*Chemiker Zeitung*



REMARKABLE PERFORMING AUTOMATA.

## REMARKABLE AUTOMATA.

THE wonderful exhibition at the "Home of Mystery," in the Egyptian Hall, Piccadilly, London, where Mr. John Nevill Maskelyne and Mr. John Algernon Cooke present their series of contrived illusions to nightly crowds of interested spectators, has, says the *Illustrated London News*, been a popular London entertainment these five or six years past. It will not soon be forgotten that Mr. Maskelyne, who is a zealous opponent of the "mediums," "clairvoyants," and necromancers of different pretensions, contributed to their practical defeat, in several instances, by proving that he knew how to produce the same appearances without the aid of "the spirits." This was a public benefit added to the continual supply of harmless amusement, not without stimulating a desire for scientific knowledge, through the honest performance of what are ironically styled "Modern Miracles" at the Egyptian Hall. We give an illustration of four ingenious mechanical figures, apparently self-acting or automatic, which have been admired by thousands of curious and wondering visitors, and the secret of whose motions, evidently guided by intelligence and consistent purpose, no one has been able to guess. These are Psycho,

the Hindoo whist-player, card-player in general, and arithmetician; Zoe, a pretty little lady in Greek costume, who writes and draws portraits; Fanfare, the cornet-player, and another musician, named Labial, who performs on the euphonium, these sometimes playing in company with their human masters, executing duets or trios. The figures are too small for even a little boy or girl to be concealed inside them, and they are placed on glass pedestals, which might be supposed to preclude any communication with them by wires, cords, or tubes. That there is some kind of hidden clockwork, we can hardly doubt; but the marvelous control of the various movements by an intelligent mind, somehow or other directing the machinery, is really worth consideration. All we can say about it is that Messrs. Maskelyne and Cooke are very clever men, and fully deserve the patronage they have so fairly won.

## JARDINIÈRE IN SILVER.

WIDTH from handle to handle 0.56 m. Worked in massive silver slightly oxidized without gilding.—*The Workshop*.

## PHOTOGRAPHY IN NATURAL COLORS.

ACCORDING to promise, I give you herewith a full detailed description of Mr. J. Albert's new invention, which Dr. Vogel has mentioned already in his report of the last Exhibition in Nuremberg.

Mr. Albert has solved the problem of reproducing natural colors in photography by combining his printing process, the Albert-type, with the chromotypie. I presume that all your readers are already acquainted with the Albert-type, and I need not say anything further about that process.

To make Albert's new process clear to you, I have to recapitulate some well-known facts in the chromotypie. We all know that the different colors appearing, for instance, in an oil painting, can be reduced to the three principal colors—red, blue, and yellow. By printing those three colors one above the other on the same sheet of paper, we will receive a kind of black; yellow and blue will give green; red and blue, violet. Every picture is, therefore, a mixture of the principal colors, which appear, of course, on different places in different shades or tones. To reproduce a picture by way of chromotypie, as many lithographic stones are used as colors appear in the original.



JARDINIÈRE IN SILVER.—DESIGN OF O. GIRARD.—BY CZOKALLY, VIENNA.

Albert follows in his invention exactly the way of chromotype; but instead of using lithographic stones, he has his printing plates commonly used for the Albert-type. Instead of being obliged to use as many plates as colors in the original, he needs only three plates, each plate reproducing respectively the three principal colors. New and interesting for us is the manner he adopts for securing plates which can produce such wonderful effects.

Already, a couple of years ago, a Frenchman, Mons. Ducos du Hauron, tried the experiment of making colored pictures by aid of photography. He influenced his negatives during the exposition by a red, green, or violet glass, expecting that the red light should produce the strongest effect on the negative influenced by the red glass; but the result showed the contrary, since we know that the red light has the least effect on a negative. Albert remembered in time a discovery of Dr. Vogel, that every collodion can be made sensitive for red or yellow light by mixing it with certain aniline colors. Using this discovery, and trying over and over again the effect of colored glasses on negatives prepared with mixed collodion, Albert adopted the following way as the best for receiving the three necessary original negatives:

He takes from a colored object (for instance, an oil painting) three negatives of the same size and focus, the first one with a collodion sensitive for all colors except red; this negative must be taken under a green glass, and will give the printing plate for red, because all colors had their effect on this negative except red and those colors which are composed of a mixture of red with another color; orange, for instance, as a color, being composed of red and yellow, will have a little more on the negative than red. The second one with a collodion sensitive for all colors except yellow and its mixture colors. This negative must be taken under a violet glass, and will give the plate for yellow. The third one with a collodion sensitive for all colors except blue; this negative has to be taken under a red glass, and will give the plate for blue.

These three colorless, original negatives indicate by different shades and half-tones the different varieties of light, dark, or mixed colors in the original. Albert makes from these negatives three plates fit to be used for the process of Albert-type. The first plate will be rolled in with red printing color, the second with yellow, the third with blue. Plates thus prepared are printed one over the other on the same sheet of paper, exactly in the same way as in the chromotype, the printer taking express care that the outlines of the prints fit exactly one in another. The result will be that the colors of the print correspond in mathematical exactness with the colors of the original.

These are, in short, the main points of the new invention, which will have undoubtedly a great future. You can imagine, Mr. Editor, what an immense deal of labor, of patience, and of perseverance were necessary to overcome all the difficulties, not to forget the heavy expenses, considering how many silver baths were spoiled daily and had to be spoiled in trying the different mixtures of collodion. In spite of all, Albert has succeeded so far, and the future alone will show to how many branches of industry this new invention will be usefully applied.—OSCAR VON KRAMER, in *Philadelphia Photographer*.

#### CONDENSED MILK.

SEVERAL parties have written to the *New England Farmer*, during the past few months, asking for information concerning the manufacture of condensed milk. The process of condensing milk was invented and patented many years ago by Mr. Gail Borden, but the patent has now expired, and the right to manufacture is free to all. The business of condensing milk in this country has never reached a great magnitude, partly because of the comparatively large amount of capital required for successfully carrying on the business, and partly on account of the limited demand for the manufactured goods. We have been able to learn of less than a dozen factories in the United States, although there may be more.

Among the largest concerns are the New York Milk Condensing Company, of New York city; that of W. K. Lewis & Co., West Brookfield, Mass.; that of Wm. Munson & Son, Baltimore, Md.; and another at Elgin, Ill. Though an American invention, the process is now carried on quite extensively in Switzerland and other European countries where cheap labor and cheap material make it possible for foreign manufacturers to compete successfully in our own markets. The duty imposed upon the sugar used in the manufacture of condensed milk, and on the tin plate of which the cans are made, is so much higher than the duty upon imported milk that at present there seems little encouragement offered to manufacturers here. The business has, undoubtedly, been profitable in years past, but the foreign milk is offered so cheaply now that the demand for our own manufactures has seriously fallen off.

The process of manufacture is quite simple, but the greatest care is required in keeping the supply of fresh milk, as it comes in from the farms, pure and sound. Every lot is carefully inspected, and any sample that is found to be imperfect is rejected before it has a chance to spoil all the rest. After being accepted it is strained two or three times to remove all possible impurities. It is then heated in large vats having copper coils of steam pipe in the bottom, after which, one and a quarter pounds of the best granulated sugar is added for each four quarts of fresh milk. It is then drawn into a vacuum pan capable of holding several thousand gallons, where it is reduced to one-fourth its normal bulk. It is then allowed to cool down to a temperature of 70°, when it is ready to draw off into pound cans, which are sealed by soldering. Good, sound milk, put up in this way, will keep for a long time, and is used very extensively on shipboard, both by travelers and seamen. It is also used largely by city residents who are suspicious of ordinary city milk, especially for feeding to infants and young children. There is, also, considerable sale for plain condensed milk, but unless sugar is used in its manufacture it will not keep for any great length of time.

The apparatus required in a factory capable of converting 5,000 gallons of crude milk per day, has cost some ten thousand dollars, while the buildings would require an additional outlay of about one-fourth that amount. Condensed milk is sold in our cities at retail for twenty-five cents per pint can, each can holding one pound, and representing two quarts of fresh milk. The manufacturer's price is twenty-five to thirty-three per cent. less in large quantities. It will be seen that the business cannot be carried on at a profit, except in localities where abundant supplies of pure fresh milk can be furnished daily through the year.

It would seem that the milk condensing business, in conjunction with the manufacture of beet sugar, might yet become a profitable business in this country. Sugar is needed for preserving the milk, cows are needed for consuming the

refuse pulp from the beets, and manure is needed for growing the beets. Sugar making could be carried on for two or three months in the fall and early winter, without greatly interfering with the regular work of the establishment. We understand that the West Brookfield, Mass., factory, was, at one time, engaged by parties interested in beet sugar making, but so little encouragement was received from the farmers in the vicinity that the project was abandoned.

THE Springfield Union says: "The shipping of apples to Europe has not yet advanced the price. On the contrary, apples are cheaper to-day than they were two weeks ago, good greenings selling by the quantity for about seventy-five cents a barrel. A dealer in this city who was refused a lot of about one hundred and fifty barrels at ninety cents a short time ago has just bought the same lot for sixty-five cents exclusive of barrels. Many grocers are holding on for better prices."

ALTHOUGH the cotton crop in the Southwestern States is estimated to be one of the largest ever known, much of it will go to waste because there are not hands enough to gather it. The present epidemic has seen the yellow fever spread among the colored people for the first time to any extent, and it has caused such a panic among them that they hug the towns, and will not be tempted into the cotton fields by wages at which they could earn five dollars a day.

THE Amherst experiment of raising the early amber cane for sirup shows an average product of 160 gallons per acre, though some pieces have yielded as high as 256 gallons per acre. The percentage of grape sugar was found to be less when fresh cut and ground than after lying for awhile before being ground; and it is hoped that improved culture may increase the percentage of cane sugar. The cost of manufacturing the sirup this season has been 35 cents a gallon, but, with better facilities for making, the cost can be reduced one half. The seed of the cane is said to be equal to oats for stock, and the young cane is claimed by some to be better than sowed corn for green fodder for cattle.

#### PROFESSOR HARKNESS, F.R.S.

THIS sudden death of this distinguished geologist took place at Dublin, on the 4th of October, 1878. Robert Harkness was born at Ormskirk, in Lancashire, in 1816. He was educated at the high school at Dumfries and at Edinburgh University. In 1853 he was appointed to the chair of geol-



ogy in the Queen's College, Cork. Professor Harkness has won for himself a European reputation by numerous important scientific researches, whilst his character and general disposition endeared him to a very large circle of friends. The portrait given in the *Illustrated London News* is from a photograph.

#### AIR TEMPERATURE.

A LECTURE was recently delivered before the Meteorological Society, London, by Mr. J. K. Laughton, M.A., F.R.A.S., the subject being "Air Temperature; its Distribution and Range." After calling attention to the importance of climatic knowledge, the lecturer dwelt on the fact that though all heat as affecting climate emanates directly or indirectly from the sun, air temperatures have but little relation to latitude, except when the distances are very great. He illustrated this by reference to isothermal and abnormal maps, and went on to speak in some detail of the several causes of the disagreement between isotherms and parallels of latitude. Locally, there is a very great difference between the temperatures of adjacent localities, on account of the sunny aspect or sheltered situation of one as compared to others, as is shown in an extreme degree by reference to such places as the Undercliff of the Isle of Wight; but geographically, a cause of very considerable importance is the nature of the soil. The air over sandy or sterile ground is heated by direct contact and by radiation to a degree far in excess of what happens to air resting on grass-grown or verdant plains, and the heat proceeding from an obscure source is unable to escape through the air, just as obscure heat rays may be caught and accumulated in closed conservatories or in a glass-covered box, so that the air may be raised to a very high temperature. Several instances are on record of a temperature of 180 deg. Fah. being observed under such circumstances. On the other hand, when the solar heat falls on ground, whether grassy or snow-covered, that will not easily part with it, the air may remain cool, or even cold, as is found in our everyday experience in summer of the pleasantness of a field path as compared with a high road, and as is shown most remarkably by the great

power of the direct rays of the sun in the Arctic, or at elevated stations in the Alps or Himalayas, whilst the snow is lying all around, and the temperature of the air is far below freezing point. But greater far than the effects of differences of soil are the effects of ocean currents, which warm the air to an almost incredible degree. Mr. Croll has calculated that the surface water of the North Atlantic, if deprived of the Gulf Stream, would be reduced to a temperature very far below freezing point; that the heat which the Gulf Stream disperses into the superincumbent air would, if converted into power, be equal to the united force of some 400 millions of ships such as our largest ironclads. This heat thrown into the air is wafted by the south-west winds over North-Western Europe, and very largely over our own country. It is this that makes the extreme difference between the climate on this side the Atlantic and that on the other; that gives us green fields and open harbors during the winter, whilst in Labrador or Newfoundland they are buried in snow or choked with ice. The carrying power of water is so great as compared with that of air, that the climatic effect of winds heated by contact with hot earth is relatively small. The sirocco of the Mediterranean—a wind heated over the great African Desert—has often been referred to as the "snow eater" of Switzerland. This has been proved to be a mistake. The snow-eating wind of Switzerland is a wind from the Atlantic, warmed by the Gulf Stream, and rendered dry and hot by the condensation of its vapor as it passes over the mountains. Similar winds have been observed in many different parts of the world; in New Zealand, in Norway, in Greenland, and in North America, where their peculiar dryness, carrying off all moisture, renders the grass so inflammable that the smallest accidental spark lights up a fire which may spread over a country, and is thus the cause of those immense prairies which are a distinctive feature of North American geography. But such winds are quite distinct from such winds as blow from the Sahara, or the stony desert of Australia, or from many other sterile tracts of country—winds which are merely the escape of air heated to an extreme degree by contact with the burning soil. These hot winds are for the most part merely disagreeable, but cold winds are very often dangerous. In the North Western States of America a cold wind, ushering in a violent snowstorm, caused the death of more than 300 people in January, 1873, and in many other localities a cold wind, bringing in a sudden fall of temperature through 40 deg. or 50 deg., is always a cause of grave anxiety. Our English "blackthorn winter" in April or May is only one and a subdued instance of the ill effects of such cold spells. The presence of moisture in the air by checking radiation from the ground by night or during the winter softens the rigor of the seasons, makes the summers less hot, the winters less cold. It is this that constitutes the difference between "insular" and "continental" climates. It is the want of the vapor screen which causes those excessive climates such as we read of in the East, where, as near Khiva, a summer of more than tropical fervor is succeeded by a winter of Arctic rigor. In a very extreme degree the climate of Astrakhan contrasts with that of Fuego; and yet the mean temperature of the two is about the same; but in the one the seasons are excessive, in the other the difference is but small. The difference in the produce of the two countries is thus very great—in the one hardy plants, requiring great heat, but able to withstand the cold; in the other plants of a more tender nature, which can flourish with a very moderate amount of warmth: in the one grapes and corn; in the other fuchsias and veronicas. In studying climate it is, therefore, necessary to observe, not only the greatest heat and the greatest cold, but also the mean temperature. These can only be observed by means of thermometers, for personal feelings may be the effects of many other causes, of wind or evaporation, or state of health, or peculiarity of constitution, and are absolutely no index to the state of air temperature. The lecturer then proceeded to speak of the different kinds of thermometers, several of which were exhibited, and of the several stands for sheltering them. The Meteorological Society has decided positively in favor of the Stevenson stand, and directs its observers to record the temperature at 9 A.M. and 9 P.M., as well as the highest and lowest, as registered by the maximum and minimum thermometers. He then described some novel and ingenious contrivances for automatic registering, such as the "Turn-over" of Messrs. Negretti and Zambra, and the "Chronothermometer" of Mr. Stanley, and concluded by pointing out that these instruments were but a means to an end, and that the study of climate was the study of nature in one of her most beautiful and most varied aspects.

#### THE CRATER OF VESUVIUS.

WE are indebted, says the *Illustrated London News*, to Mr. J. Eddy for the sketch we have engraved, showing the actual condition of the crater of Mount Vesuvius on the 26th of Sept., 1878. It is accompanied by the following letter, dated the 30th, from Rome: "Vesuvius having been for a long time in a disturbed condition, and the reports of an eruption growing more and more exciting, I determined to pay a visit to the mountain, and to see in what condition it really was. It is, perhaps, almost needless to say that I found everything had been very much exaggerated. This, indeed, I had expected; for any one who knows where the observatory is placed, and how Professor Palmieri stayed there, unmoved by the terrible eruption of 1872, will find it difficult to believe that he would now spend his time in building a dike around his observatory, as the telegrams reported. Still, the visit was not unsatisfactory, for I was able to descend into the old crater, which would, of course, have been impossible in a great eruption, and to see the new cone and the small eruption which is actually going on. Leaving Naples with a friend, we drove up as far as what used to be the Hermitage, now deserted by the monks, who have been expelled even from that solitude by the Italian Government. Here we left our carriage at a small inn, and took horses to the foot of the cone, accompanied by a crowd of guides, who, however, soon tailed off, leaving us with the three who were chosen to go up with us. At the foot of the cone we were beset by as many more of them. My friend, after about fifty yards of ascent among the loose ashes, found it too fatiguing, and consented to be hauled up. This encouraged others of the loafers to follow us, in hopes of my doing the same; but, finding that it was a waste of time, they soon left us. The climbing is certainly tiring, like walking through loose sand on the seashore, with a stiff hill thrown in; but, with a little patience, one works one's way on. The crater was so filled with smoke that we determined to descend into it to see what was to be seen. Half way down, when we got in sight of the new cone throwing up flames and showers of red hot stones, I confess to feeling rather nervous about continuing the descent, and I think it was excusable; but the guides said that there was no need for

alarm, and that other people were already down there, so we went on. The floor of the old crater has in the last few weeks risen a considerable height, and is still rising, for when we reached it there were two or three small streams of lava cozing out of cracks in it, and slowly flowing over the cooler blocks. These streams came out red hot, but soon turned to the dull lead color of the rest of the lava; only directly you stirred them up they became glowing like fused metal. The floor itself is full of cracks, showing the lava red hot at about a foot or two beneath the surface; and even where we stood you could not bear the hand on it long. At the upper end of the hollow is the new cone, which forced its way up suddenly, and keeps up a continuous shower of lumps of red hot lava. The more violent explosions throw up to the height of a hundred feet or so, with a dull, smothered report; the lesser ones throw up the liquid fire some twenty or thirty feet; and as the pieces of lava fall on the sides of the cone they turn black almost instantly, and help to raise the little hill in height. The cone is quite black, and about fifty feet high. One theory is that it will grow until it fills the present crater, and take the place of the old cone, as the old one did that of the left hand cone in the year 79, when Herculaneum was destroyed. In front of the cone is a mass of rock which lately fell from the sides of the crater. At the opposite end of the crater, and therefore not visible in the small sketch I took, is a sort of gap in the walls of the crater, through which the lava is expected to flow. At present it will have to rise about 20 feet before it reaches the gap, unless the side should crumble away under the great heat and pressure. This gap is on the side toward the hollow or ravine which divides the two crests of the mountain; and the lava would therefore take the course it followed in 1872, toward the observatory and San Sebastiana. At present the activity of the eruption has

ing down on its sides, make them rise higher every day. The wind fortunately blew the smoke away from us, or otherwise we would have been almost if not quite suffocated where we stood—about thirty yards from the base of the cone; and we were able to enjoy the wonderful sight, which, as a man who followed us down said, one could stay all day to look at. Accompanying the bursts of the flame were hollow reports, not loud, as I had expected, but smothered, stifled explosions; and as I climbed up the side of the crater, so as to be able to look more into the mouth of the new cone, I could see through the smoke a struggling confusion of flames, which found vent in the ejection of the burning liquid. The crater walls are brilliant with yellow and orange colored sulphur, mixed with basalt and red lava and white salts, forming a bright contrast to the leaden colored lava which forms the floor, and the black cone with its crown of smoke."

#### CHARLES ADOLPHE WURTZ.

In connection with the Faraday Lecture which follows, it may interest our readers to have a few particulars as to the life and work of the lecturer, Prof. Wurtz.

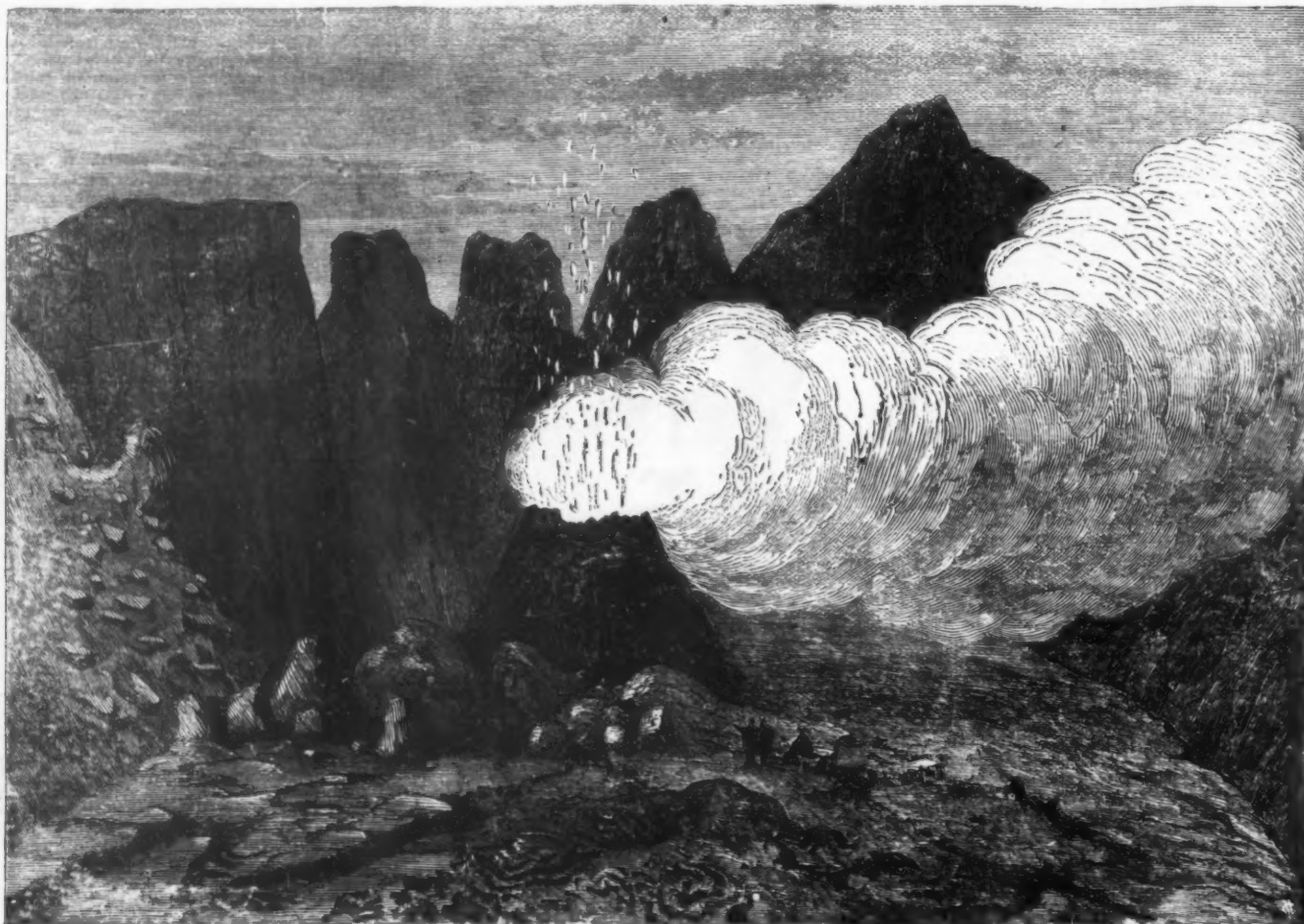
Charles Adolphe Wurtz was born at Strassburg on November 16, 1817. He commenced his chemical career as assistant to Dumas, and first acquired an independent position as Professor at the Agricultural Institute at Versailles. For the last thirty years he has been Professor of Chemistry at the Ecole de Médecine, Paris; in addition to which he now holds the post of Professor of Chemistry at the Sorbonne.

Professor Wurtz is a member of the Institute (Académie des Sciences), and a foreign Fellow of the Royal Society.

Some idea of the energy which he has displayed as an investigator is conveyed by the fact that a list of no less than seventy-three titles of papers is appended to his name in

on the alcohol radicles published in 1855. Frankland had shown that the hydrocarbon radicles which it was assumed were contained in the alcohols could actually be isolated; that, from ordinary or ethyl alcohol, for example, which may be regarded as a compound of the radicle ethyl,  $C_2H_5$ , with the radicle OH, we may obtain ethyl by acting with zinc on the iodide which it yields on treatment with hydriodic acid, thus withdrawing the iodine from it, just as the iodine is withdrawn from the hydrogen in hydriodic acid by the action of metals; and Kolbe had obtained similar results with acids, such as acetic acids, by submitting solutions of their salts to the action of a powerful electric current. These chemists, however, supposed that the radicles thus withdrawn from combination with other radicles remained in the free state, but Laurent and Gerhardt, and Hofmann argued on theoretical grounds that the bodies thus produced were not the radicles themselves but compounds of the radicles with themselves—that ethyl, for example, was not  $C_2H_5$ , but  $C_2H_4$ , or  $C_2H_2 + C_2H_4$ . Conclusive evidence of the correctness of this latter view was afforded by Wurtz's discovery that if a mixture of the iodides of two different radicles were treated with metallic sodium, a hydrocarbon formed by the union of the two different radicles was obtained. This discovery has afforded one of the chief arguments in favor of the view now almost universally entertained by chemists, that free hydrogen is a compound of hydrogen with hydrogen.

The mere recapitulation of the titles of his remaining investigations would alone occupy a large amount of space. We can only refer to those on the glycols and on ethylene oxide; on the action of nascent hydrogen on aldehyde; on the action of chlorine on aldehyde, both in the anhydrous state and in presence of water; on the action of hydrochloric acid on aldehyde; on the synthesis of neurine; and



THE RECENT ERUPTION OF MT. VESUVIUS.—SKETCH BY MR. J. EDDY.

so much diminished that there is little probability of the lava flowing down the sides of the mountain."

We are indebted for the foregoing to the *Illustrated London News*.

A correspondent of the New York *Herald* writes as follows: "I started with a friend to make the ascent. It rained until we reached the observatory, and then, fortunately, the day became delightful. It is a weary climb up, though, through the loose ashes; and one is attempted to halt and admire the view pretty often before reaching the top. When we had reached it we could see nothing for the smoke and mist that filled the big crater; while far beneath us we could hear the lava seething, and frequent explosions from the new cone. We were advised at starting not to descend into the crater; but our guide assured us that we could quite safely do it, so down we scrambled on to the lava. The floor of the crater has risen in the last few weeks from a considerable depth to within about twenty feet of a gap in the side of the crater wall, looking toward the old left hand cone of Vesuvius; and it is still rising. As we stood on the comparatively cool blocks of lava the fresh red hot stream was slowly flowing out from cracks around us, moving on in a snake-like, fascinating way, and breaking out in a fresh place as soon as the flow stopped elsewhere. Every crack showed the lava red hot a foot or two beneath us, but the guides ran about on it and we followed them, as if we were on the level Campagna. At the upper end of the old crater—that is, just underneath the highest point of the old cone—is the new cone, which has risen in the last week or so; a baby cone, about fifty feet in height and perhaps one hundred and ninety yards in circumference at the base, but a very noisy and fiery cone, sending out continual puffs of smoke rosy with the flames which frequently rise above its summit, and hurling into the air to the height of one hundred feet or so lumps of red hot stone and lava, which, fall-

the Royal Society Catalogue, which only includes papers published previous to 1864. Much of his work is of the first importance in connection with chemical theory, and he undoubtedly takes rank as one of the chief pioneers of modern organic chemistry.

His first investigation, published in 1842, was on the constitution of the hypophosphites; this was followed by researches on phosphorous acid, sulpho-phosphoric acid, etc., which greatly added to our knowledge of the phosphorus compounds. It was in the course of his experiments on the hypophosphites that Wurtz discovered hydride of copper,  $Cu_2H_2$ , one of the most remarkable hydrides with which we are acquainted, and especially interesting as, with the exception of potassium, sodium, and perhaps palladium, none of the metals appear to be capable of combining with hydrogen. Hydride of copper is formed as a yellowish precipitate on adding a concentrated solution of copper sulphate to a solution of hypophosphorous acid, and warming the mixture to about  $70^\circ C$ ; in the dry state it slowly decomposes into its constituents at about  $55^\circ C$ ; concentrated hydrochloric acid at once dissolves it with evolution of hydrogen, although copper is not in the least affected by this acid, and what is most remarkable, both the hydrogen of the acid and of the hydride of copper are given off as shown by the equation—



The study of certain cyanogen compounds—the cyanic and cyanuric ethers—next engaged his attention, and his researches on these bodies culminated in the remarkable discovery, in 1849, of the so-called compound ammonias formed by the displacement of one of the atoms of hydrogen in ammonia,  $NH_3$ , by organic radicles, such as methyl,  $CH_3$ , ethyl,  $C_2H_5$ , etc.

A third investigation to which we may here refer is that

on abnormal vapor densities, as being, among others, of especial interest.—*Nature*.

#### ON THE CONSTITUTION OF MATTER IN THE GASEOUS STATE.\*

I ESTEEM it a great honor to address you within these walls, about which there still hovers the ever fresh memory of him whose name we celebrate to-day, while we deplore his loss. I am fully sensible both of the great value of this honor and of the danger that attends it, and I have need to shelter myself under the authority of the great name of Faraday. I have, therefore, chosen a subject connected with his earliest discoveries. The constitution of matter is a question of the highest importance with regard both to physics and to chemistry.

The word "gas" was introduced into science by Van Helmont, who, at the beginning of the seventeenth century, first pointed out, with some degree of precision, the differences existing between certain aëriform fluids. He it was who first spoke of *Gas silvestre*, formed by the combustion of charcoal, and given off during the fermentation of beer. To him, also, we owe the distinction—which kept its ground for two centuries—between gases and vapors. He regarded gases as aëriform fluids, incapable of reduction to the liquid state by cooling, whereas vapors require the aid of heat to maintain them in the gaseous state. An important difference of constitution seemed, therefore, to exist between these two kinds of aëriform fluid. This difference, however, is not fundamental, and the distinction between gases and vapors has disappeared, in a theoretical point of view,

\*The Faraday lecture, delivered before the Fellows of the Chemical Society, in the Theater of the Royal Institution, on Tuesday, November 13, 1878, by Ad. Wurtz, Membre de l'Institut; Doyen Honoraire de la Faculté de Médecine de Paris.

being, in fact, reduced to a simple question of temperature and pressure.

On March 18, 1823, Faraday, then a young man engaged as chemical assistant at the Royal Institution, read before the Royal Society a note entitled "On Fluid Chlorine." He had succeeded in condensing this gas to a liquid by a process which has become classical. This process consists in heating in a closed vessel placed in a water-bath crystals of chlorine hydrate. This compound, very rich in chlorine, is resolved at a gentle heat into chlorine and liquid water, the quantity of which is not sufficient to dissolve the whole of the chlorine. The latter is, therefore, disengaged in great part in the state of gas, which accumulates in the small space remaining to it, and is liquefied by the pressure which it exerts upon itself.

On the same day Sir Humphry Davy read a note "On the Liquefaction of Hydrochloric Acid Gas," which he effected by decomposing sal-ammoniac with sulphuric acid in a closed vessel. These researches were completed by Faraday, who, on April 10 of the same year, described the liquefaction of a large number of gases, directing his efforts, by Davy's advice, chiefly to those which are dense, or very soluble in water, such as sulphurous acid, ammonia, sulphureted hydrogen, carbonic acid, and protoxide of nitrogen.

To enumerate the special processes adopted in each particular case would occupy too much time. We shall, therefore, merely observe that the chief, if not the only, means of condensation adopted in these experiments was compression, that is to say, the reduction of the gas to a small volume, and that this compression was exerted by the gas upon itself, as it accumulated in the very strong sealed glass tubes in which it was disengaged. Sir Humphry Davy, in the note above cited, had remarked that pressure appeared to be a more efficacious method of condensation than cooling, inasmuch as a double pressure reduces the volume of the gas to one-half, whereas a depression of temperature of 1° F. reduces the volume by only 1-480, the lowering of temperature, moreover, soon attaining an impassable limit. It must, however, be especially observed that, even in his first experiments, Faraday made use of differences of temperature, if not to liquefy the gases, at all events to distill and isolate the liquids. Thus it was in the case of chlorine, for example, and in that of ammonia, which he liquefied by heating ammoniacal silver chloride in a bent tube sealed at both ends, the liquid ammonia then distilling over and collecting in the empty branch of the tube, which was cooled to a low temperature.

Similar phenomena will be exhibited in the experiment which I am about to show you, consisting in the liquefaction of cyanogen gas by heating cyanide of mercury in a small glass tube terminated by a long capillary tube bent in the form of the letter U. The figure of this curved portion will be projected on a screen by the electric light, and in a few seconds you will see the liquid cyanogen collect in the bend.

Before leaving this part of my subject, I would recall to your attention two of Faraday's discoveries resulting from the application of the principles just explained. Having compressed coal-gas to twenty-five atmospheres, Faraday in 1825 discovered two important bodies, namely butylene, a compound of great importance, in a theoretical point of view—and benzene—so named by Mitscherlich several years afterward—which in our own time has become the object of numerous and important applications, and the pivot of an entire department of chemistry.

Another instance is afforded by sulphurous acid gas ( $\text{SO}_2$ ), which was liquefied by Bussy in 1824, at the ordinary atmospheric pressure, by the effect of a cold of 12° to 15° below zero.

Whether we condense gases by pressure or reduce them to the liquid state by diminution of temperature, the result of either method is to bring their particles closer together. It would seem, then, in accordance with Davy's view, that pressure ought to be more efficacious, as a means of condensation, than cooling. Nevertheless it is not so. The mere approximation of the particles of certain gases does not suffice to effect their liquefaction, and moreover, the distances between the particles cannot be diminished indefinitely by pressure alone. M. Natterer, of Vienna, has compressed oxygen, hydrogen, and nitrogen to 3,000 atmospheres without effecting their liquefaction. These gases, hitherto called permanent, cannot be liquefied by pressure alone, and their liquefaction, which has quite recently been effected, is the joint effect of strong pressure and a great degree of cold. This is the important point, and I request your permission to offer in this place a few explanations which will serve to place it in its true light.

The impossibility of liquefying certain gases by pressure alone is in accordance with the ideas which are current at the present day respecting the nature of aeriform fluids, and likewise with a discovery made in England within the last few years, on the continuity of the gaseous and liquid states. I will explain myself briefly on these two points.

Daniel Bernoulli first enunciated the idea that gases are formed of material particles, free in space, and animated by very rapid rectilinear movements, and that the tension of elastic fluids results from the shock of their particles against the sides of the containing vessels. Such is the origin of the kinetic theory of gases, which has been revived since 1824 by Herapath, Joule, and Krönig, and developed chiefly by Clausius and Clerk Maxwell.

The law of Boyle and of Mariotte follows as a natural consequence of this idea. Suppose a gas occupying a certain volume, and composed of a definite number of material particles—or molecules so-called—to be contained in a closed vessel, such as the cylinder of an air-pump, the pressure on the piston will be determined by the number of shocks of the molecules diffused through the neighboring stratum of gas. If, then, the volume of gas be reduced, the number of particles in this layer will be increased, as well as the shocks, and the pressure will be increased in proportion thereto.

The velocities with which these molecules move are enormous. Clausius supposes that the molecules of air move with a mean velocity of 485 meters per second, and those of hydrogen with a mean velocity of 1,844 meters per second. I say mean velocity, for all the particles of a gas do not move at the same rate. But can the particles freely traverse these wide spaces? By no means; their number is so immense, that at every instant they enter into collision with one another, and rebound in such a manner that their motion is altered both in velocity and in direction. It follows, therefore, that the molecules of a gaseous mass are continually moving in all directions with variable velocities, their motion in the intervals between the collisions being sensibly rectilinear. The distribution of the velocities has been made the subject of important researches by Clerk Maxwell.

These movements of gaseous molecules determine a very

important physical condition, namely, temperature. In fact, the energy of the rectilinear movements, that is to say, the mass of the gaseous molecules multiplied by the square of their velocity, gives the measure of the temperature, which consequently increases proportionally to the energy of the rectilinear movement, or, for the same gas—since the masses remain constant—it increases as the square of the velocity. If the velocity were reduced to nothing, the calorific motion would be annihilated, that is to say, the gas would be entirely deprived of heat. This state corresponds with the absolute zero.

The gaseous molecules moving in all directions and coming into collision with one another in space, are very nearly emancipated from cohesion. Nevertheless this attractive force makes itself felt for the infinitely short time during which the molecules actually touch one another, or are on the point of doing so. This influence of cohesion is one of the causes of deviation from the law of Boyle or of Mariotte.

In liquids the influence of cohesion is manifest, preventing the molecules from separating, though it allows them to glide one over the other. This molecular cohesion, or attraction, is in continual strife with the force of expansion, or kinetic energy, which, if unopposed, would launch the molecules into space.

To understand the antagonism between these two forces, consider for a moment a saturated vapor in contact with the liquid from which it has been formed. When it is reduced to a smaller volume, a certain number of its molecules are brought within the sphere of action of cohesion; they are consequently aggregated together and precipitated in the liquid state, while the rest, being now diffused through a wider space, continue to move with the same velocity and to exert the same pressure as before. In this case the force of cohesion of the liquid particles exactly balances the expansive force or kinetic energy, and serves to a certain extent as a measure of its amount.

Now let the vapor be heated, after it has been withdrawn from the action of the liquid; its expansive force will then increase; it will dilate, and may then be compressed, until, by the approximation of its particles, it is again brought within the sphere of action of the cohesive force, that is to say, to the point of saturation corresponding with the temperature to which it has been raised. With the increase of temperature, the expansive force or kinetic energy of the vapor likewise increases, whereas the cohesion of the liquid becomes less; hence the necessity of further diminishing the distances between the particles by increase of pressure. But this double effect of increased kinetic energy of the gaseous molecules, and diminished cohesion of the liquid molecules, going on progressively as the temperature rises, a point will at length be attained at which the energy of the molecular movement will finally gain the victory over the force of cohesion, *whatever be the pressure to which the vapor is subjected*. The minimum temperature at which this effect is produced, and at which, therefore, a vapor can no longer co-exist with its liquid under any pressure whatever, has been called by my friend, Dr. Andrews, the critical point, and by M. Mendeleeff, the absolute boiling point. Above this temperature, whatever may be the pressure, the gas, whether dilated or compressed, will maintain the same physical state, characterized by freedom of molecular or calorific movement.

I can show you by an experiment this peculiar phenomenon of the sudden passage of a liquid mass to the state of gas, by heating liquid carbonic acid in a closed vessel, just as Cagniard de Latour formerly heated ether. Here is a tube, half filled with liquid carbonic acid, which we are about to immerse in water at 35°; you observe that the liquid first rises quickly in the tube, its coefficient of expansion being greater than that of gases; at the same time the meniscus flattens more and more, indicating a diminution of cohesion in the liquid (Andrews), and finally disappears altogether; in fact the liquid itself has disappeared, having been entirely and suddenly transformed into gas. What now must we do to cause it to reappear? We must lower the temperature, so as to diminish the kinetic energy of the gas, and increase the cohesion of the liquid. A moment will then arrive when the cohesive force will again be able to resume the contest and the liquid will be reconstituted.

#### LIQUEFACTION OF OXYGEN AND HYDROGEN.

We are now in a position to understand why certain gases, hitherto called permanent, cannot be liquefied except by the combined action of very strong pressure and a very great degree of cold. The critical points of these gases are situated at very low temperatures. They have quite recently been liquefied, this great discovery having been made by MM. Cailliet and Raoul Pictet.

The principle of Cailliet's apparatus is the following: The gas to be liquefied is introduced into a cylindrical glass vessel, and transferred by means of mercury to a very strong glass tube sealed into the reservoir. This latter is firmly fixed in a cylindrical cavity hollowed out of a block of iron, and serving as a kind of closed mercurial trough. The cylindrical cavity communicates with a hydraulic press which injects water on to the surface of the mercury, driving it into the gas reservoir, which is ultimately quite filled with that liquid, the gas being thereby driven into the tube, where it is liquefied.

In this manner we shall be able by a few strokes of the piston of the hydraulic press to liquefy carbonic acid. Other gases less easily condensable may be liquefied in a similar manner if the tube be cooled to -20° or -30°. But these temperatures do not suffice for the liquefaction of the so-called permanent gases. To cool these gases to lower temperatures M. Cailliet avails himself of sudden expansion (*détente*). The gas, compressed to several hundreds of atmospheres, when allowed to expand suddenly and drive the air before it, consumes a certain quantity of heat, and is thereby reduced to a kind of mist, which will appear on the screen, and pass away like a cloud, if we suddenly expand the strongly compressed carbonic acid gas, which we have here, in default of oxygen or hydrogen.

M. Raoul Pictet has succeeded in condensing oxygen and hydrogen in the form of liquids, properly so called, and even in obtaining the latter of these gases in the solid state. To produce this effect, he employs condensing apparatus of incomparable power, combining the action of a cold of 120° to 140° below zero with that of enormous pressures amounting to 550 and even 650 atmospheres. The pressure is produced by the accumulation of the gases in a closed space consisting of a long copper tube of very thick metal. The oxygen was produced by heating potassium chlorate in a howitz shell, having a copper tube soldered into its orifice. The hydrogen was prepared in a similar apparatus, by decomposition of a dry mixture of potassium formate and potassium hydrate.

To produce very low temperatures of 120° or even 140° below zero, M. Pictet resorts to a very ingenious artifice. Over the reservoir tube which surrounds the copper tube, and in which these low temperatures are intended to be produced, he superposes another system of concentric tubes, intended to produce a first fall of temperature, amounting to -65°, by the volatilization of liquid sulphurous acid. By means of this first depression of temperature it has been found possible to liquefy carbonic acid gas in the inner tube of the system just mentioned by a pressure of only a few atmospheres. The carbonic acid thus liquefied being introduced into the lower reservoir tube of the apparatus produces by its volatilization a second fall of temperature round the copper tube containing the compressed oxygen which is to be liquefied.

M. Pictet has, in fact, established a double circulation, one of sulphurous acid, the other of carbonic acid. I will describe the former:

Sulphurous acid gas is liquefied by a pressure of three atmospheres, and collects in a strong vessel, from which it passes through a tube into the upper reservoir. The pressure is exerted by means of a force pump. A suction pump connected with the force pump, and acting in concert with it, withdraws the liquid sulphurous acid from the reservoir tube, and transfers it to the force pump, which brings it back to the vessel, and thence to the upper reservoir tube.

The circulation of the carbonic acid is established in the same manner, by means of two pumps, one of which condenses the gas by forcing it into tubes cooled to -61°, while the other, which is a suction pump, sends it back to the force pump. The volatilization of the carbonic acid produces round the copper tube the low temperatures above mentioned. The copper tube is in fact surrounded by solid carbonic acid.

In this manner M. Pictet has liquefied oxygen, and has approximately calculated its density. He has also liquefied and even solidified hydrogen, which he has seen to issue from the tube in the form of a steel-blue liquid jet, which partly solidified. The solid hydrogen, in falling on the floor, produced the shrill noise of a metallic ball, thus confirming the bold and ingenious idea of Faraday, who first suggested that hydrogen is a metal.

The experiments of MM. Raoul Pictet and Cailliet have, then, removed from science the distinction between permanent and condensable gases. Permanent gases exist no longer. All aeriform fluids may be liquefied with a facility greater in proportion as their critical points are situated at higher temperatures. From a physical point of view, therefore, gases and vapors have the same constitution, being formed of molecules which move freely in space. In what, then, do they differ? They differ by the nature and constitution of these molecules; and here we enter on the domain of Chemistry.

It is supposed, in chemistry, that the molecules of each species of gas or vapor are formed of a definite number of atoms. The simplest molecules, like those of mercury vapor, are formed of single atoms. Others include several atoms of the same or of different kinds, and these latter molecules may be very complex, that is to say, formed of a large number of atoms held together by affinity, and vibrating in concert in a system to which they are attached, viz., the molecule. In this system, which has a definite form, extent, and center of gravity, the molecules execute their own proper movements, and are at the same time carried forward with the entire system in the molecular path.

I cannot here dilate on the nature and chemical properties of the several gases and vapors. I wish merely to throw light on a single point, which is of great importance, inasmuch as it constitutes one of the foundations of chemical science.

The proposition which I am about to enunciate is generally adopted by chemists, resting as it does on an imposing array of facts:

Equal volumes of gases or vapors, under the same conditions of pressure and temperature, contain equal numbers of molecules.

The Italian chemist, Amadeo Avogadro, in discussing the discoveries of Gay Lussac respecting the simple relations which exist between the volumes in which gases combine, was the first to recognize that there likewise exists a simple relation between the volumes of gases and the number of molecules which they contain. The simplest hypothesis, said he, that can be made regarding this matter, consists in supposing that all gases contain in equal volumes equal numbers of "integrant molecules." By this term he denoted what we now call simply molecules, and he distinguished these integrant molecules from the "elementary molecules," which we call atoms. According to him the integrant molecules of gases are all equally distant one from the other, and these distances are so great in proportion to the dimensions of the molecules, that the mutual attraction between the latter is reduced to nothing.

These integrant molecules are composed of a greater or smaller number of elementary molecules, not only in compound, but likewise in simple bodies. The integrant molecules of chlorine, for example, are composed of four elementary molecules, and the same is the case with the integrant molecules of hydrogen. What happens, then, when chlorine and hydrogen combine together? The integrant molecules of these two bodies are then resolved into elementary molecules, which combine, two by two, to form hydrochloric acid.

Ideas analogous to those of the Italian chemist were enunciated in 1814 by Ampère, and thus there has been introduced into chemical science the notion that there exist two kinds of small particles, namely, molecules and atoms, the former being diffused in equal numbers through equal volumes of gases.

But this notion, so clearly enunciated more than sixty years ago, was afterward destined to be obscured. Berzelius, taking up Ampère's proposition, altered it by substituting atoms for molecules, and saying that "equal volumes of gases contain equal numbers of atoms." This proposition, which has given rise to long discussions, must now be rejected, for it is inexact. It is to Gerhardt, and more recently to Cannizzaro, that is due the honor of having restored the thesis of Avogadro and Ampère, and pointed out its importance in connection with chemical theory. This I must explain in conclusion.

In the first place Gerhardt simplified the rule of Avogadro. The latter supposed that a molecule of chlorine or of hydrogen contains four atoms, whereas Gerhardt regards it as consisting of two. Avogadro's proposition thus modified, assumes a very simple form, and may be enunciated in the following terms:

Suppose that a volume, or the unit of volume, of hydrogen contains one atom; then the molecules of all gases and vapors will occupy two volumes. Thus a molecule of hydrogen formed of two atoms will occupy two volumes, and

a molecule of chlorine formed of two atoms will likewise occupy two volumes. What now will happen when chlorine combines with hydrogen? The molecules will be cut in two, and each of the two chlorine atoms uniting itself to an atom of hydrogen, two molecules of hydrochloric acid will be formed, each occupying two volumes. Thus if an atom of hydrogen occupies one volume, a molecule of hydrochloric acid will occupy two volumes. The same is the case with the molecules of all other gases and vapors.

A molecule of water formed of 2 at. H and 1 at. O } occupies  
 ammonia " 3 at. H and 1 at. N } 2  
 marsh gas " 4 at. H and 1 at. C } volumes.

This list might be prolonged by taking as examples a large number of gaseous or volatile bodies belonging both to mineral and to organic chemistry, and including chlorinated, brominated, and oxygenated compounds of the metalloids, and of a large number of metals. The countless volatile compounds of organic chemistry, hydrocarbons, alcohols, chlorides, bromides, organo-metallic compounds, compound ammonias, aldehydes, ketones—all this legion of various compounds—conform to the law of Avogadro and Ampère, their molecules occupying two volumes if an atom of hydrogen occupies one volume. Hence it follows that the relative weights of two volumes represent the relative weights of the molecules, or the molecular weights. To find these latter, therefore, it is sufficient to double the numbers which express the weights of a single volume, or of the unit of volume, that is to say, the densities. The densities of gases may be referred to that of hydrogen as unity, and the atomic weights to that of hydrogen. The unit being, then, the same, it follows that the numbers which express the double densities referred to hydrogen will also represent the molecular weights.

Chemists represent the constitution of molecules by formulae, each of which shows the number of atoms condensed within the molecule. Now, the molecular weights being known, it is very easy to deduce the formulae from them, as these formulae must represent the number of atoms comprised in two volumes.

Such is the relation which exists between the law of volumes and chemical notation. The rule of Avogadro and Ampère has, in fact, become one of the bases of this notation. There are, however, certain exceptions to its generality, but they are probably more apparent than real. Sal-ammoniac, ammonium sulphhydrate, phosphorus, pentachloride, iodine trichloride, sulphuric acid, calomel, amylene hydrobromide, and chloral hydrate have vapor densities such that their molecules appear to occupy four volumes. Such, however, is not the case, and it may be shown that the bodies in question do not volatilize without decomposition, but that when they are heated their molecules split up into two, each of which occupies two volumes. Being unable to analyze all the cases above mentioned, I will confine myself to the last, viz., chloral hydrate, which has given rise to a long discussion.

The question to be decided is, whether this compound is or is not decomposed by conversion into vapor? If it really suffers decomposition, it should be resolved into anhydrous chloral and water. That this decomposition really takes place, may be shown by a method based on the theory of dissociation developed by M. H. Sainte-Claire Deville.

Here is the case in a few words:

We have here in a tube a certain volume of the vapor of chloral hydrate under a certain pressure; it is required to show that this vapor contains vapor of water. For this purpose we are about to introduce into it a body capable of emitting vapor of water; crystallized potassium oxalate, for example. If the atmosphere is dry, this salt will give off vapor of water just as it would in dry air or in vapor of chloroform at the same temperature, and it will continue to emit this vapor until the atmosphere shall have taken up a degree of humidity corresponding with that which is designated by M. H. Sainte-Claire Deville the dissociation tension of the hydrated salt in question. If, on the other hand, the chloral atmosphere is moist, and exhibits exactly the degree of humidity just defined, the crystallized oxalate will not emit any water.

In the first tube, then, we have the vapor of chloral hydrate; the second contains vapor of chloroform. This latter is dry, and I am about to prove to you that the former is moist. In fact, the crystallized potassium oxalate which we are introducing into the chloroform tube will rapidly depress the level of the mercury by emitting vapor of water, whereas in the atmosphere of chloral hydrate it will not emit vapor of water, and consequently will not depress the level of the mercury. This shows that chloral hydrate undergoes decomposition when converted into vapor, and this supposed exception to the rule of Avogadro and Ampère vanishes, like all the rest, when submitted to the test of experiment. This rule appears, then, like a grand law of nature, as simple in its enunciation as it is important in its consequences.

Such are the considerations which I wished to lay before you on the physical and chemical constitution of gases. Does not this exposition seem to show that, of all the states which matter can assume, the gaseous state is the most accessible to our researches, and the best known—not, indeed, that we can affirm the certainty or the theoretical considerations which I have brought before you, for they are but probable. In the physical sciences nothing is certain but well-observed facts and their immediate consequences, and whenever we attempt to make these facts the basis of any general theory, hypothetical data are apt to mix themselves up with our deductions. In the present case the hypothesis consists in assuming that gases, and matter in general, are formed of molecules, and these latter of atoms. No one has ever seen these molecules and atoms, and it is certain that nobody ever will see them. Does it follow, then, that we ought to reject or disclaim this hypothesis? By no means. Our theory may be verified in their consequences, and may thereby acquire a certain degree of probability. The theory under consideration has been subjected to this ordeal, and nothing has hitherto been found to contradict it. It is probable, indeed, that gases are composed of small particles moving freely in space with immense velocities, and capable of communicating their motion by collision or by friction. It is probable that these molecules are diffused in space in numbers so enormous that the most rarefied spaces still contain legions of them, and it is this circumstance which explains the possibility of the movements of the radiometer.

Be this as it may, the idea of Daniel Bernoulli has been developed into a beautiful theory—the kinetic theory of gases—a theory which has shed a sudden clearness, an unexpected light upon matters which seemed to be veiled in the deepest obscurity.

The molecules, as already stated, are invisible. Nevertheless attempts have been made to penetrate this invisible world by the force of scientific reasoning, and by an effort

which does honor to the human mind, even if it be destined to remain barren. The illustrious authors of the kinetic theory of gases have sought to determine, not only the velocities of the gaseous molecules, and the prodigious number of their collisions during a unit of time, but likewise their distances, their absolute dimensions, and their number in a given volume. And here we arrive at results which bewilder the imagination, but which, in this lecture, I must not attempt to unfold.

Permit me only to add that these great labors mark a resting place in our course, and are perhaps an approach toward the solution of the eternal problem of the constitution of matter, a problem which dates from the earliest ages of civilization, and though discussed by all the great thinkers of ancient as well as of modern times, still remains unsolved. May we not hope that in our own time this problem has been more clearly stated and more earnestly attacked, and that the labors of the nineteenth century have advanced the human mind in these arduous paths more than those of a Lucretius, or even of a Descartes and a Newton? From this point of view the discoveries of modern chemistry, so well expressed and summarized by the immortal conception of Dalton, will mark an epoch in the progress of the human mind, and to one of the most important among these discoveries—that of the liquefaction of the gases—grateful posterity will forever join the glorious name of Faraday.—*Nature*.

#### CHEMICAL SOCIETY, LONDON.\*

November 7, 1878.

Dr. J. H. GLADSTONE, F.R.S., President, in the chair.

"Contributions from the Laboratory of the University of Tokio, Japan: On the Red Coloring Matter of the Lithospermum Erythrorhizon," by M. Kuhara. The root of the above plant occurs in commerce in thick lumps, purple externally, but yellowish white inside. It was largely used for the manufacture of "Tokio purple," but from the fugitive character of its color and the introduction of aniline dyes its use has been almost abandoned. The root contains about 10 per cent. of glucose and 4 per cent. inverted sugar. The purple coloring matter is extracted almost completely by alcohol, and resembles in some respects anechusin, the coloring matter of alkanet. It is prepared from the root by extraction with alcohol, acidulating the extract with hydrochloric acid, and distilling off the alcohol. The impure coloring matter thus obtained was purified by precipitation with plumbic acetate, etc., in the usual way. It was finally obtained as a dark, resinous, uncrystallizable mass with a metallic green reflection. It is soluble in alcohol, ether, benzol, oil of turpentine, methylic alcohol, and carbon disulphide, but almost insoluble in water. It has a feeble acid reaction and a peculiar odor. It softens at 95° C., and then partially volatilizes in red fumes, which condense on the colder part of the tube. The alcoholic solution has an absorption-spectrum resembling that of alkanet. Stannous chloride decolorizes the solution. It has the formula  $C_{18}H_{12}O_8$ . A barium salt was prepared and decomposed. The paper also contains an account of a bromine and a chlorine compound. Further experiments are in progress.

Dr. Gladstone drew attention to the activity prevailing in the laboratories in Japan, and Dr. Frankland said that the society was much indebted to its fellows in Japan for examining substances which could not be obtained here, and such researches as the above were always very welcome.

The best thanks of the society were then given to the author for his communication.

Dr. Wright then read "A Second Report on some Points in Chemical Dynamics," C. R. A. Wright and A. P. Luff.

Dr. Frankland read a "Note on the Constitution of the Olefine Produced by the Action of Zinc upon Methyl Iodide," by Dr. Frankland and Mr. Dobbin. This short paper contains an account of experiments made to determine the question whether the gas given off in the above reaction was ethylene—



Many liters, after passing through alcohol and sulphuric acid, were led into a very large bulb-tube containing antimonious chloride. The contents of the bulb tube were finally mixed with water and distilled. The boiling point as determined by Chapman Jones' method, was 83° C., and was therefore that of ethylenic, and not of ethylenic chloride, the latter substance boiling at 60°.

In answer to a question of Dr. Armstrong.

Dr. Frankland said that although his expectations of obtaining ethylenide were certainly less than before, he should be very sorry to say that it did not exist, and would be still inclined to try further experiments if a reaction could be discovered to eliminate  $C_2H_4$  at a low temperature.

"On the Occurrence of certain Nitrogen Acids among the Products of Combustion of Coal Gas and Hydrogen Flames," by L. T. Wright. The apparatus of the London Gas Referees for determining the sulphur in coal gas was used by the author throughout his experiments. The combustion of 1,000 liters of ammonia free coal gas in a Bunsen burner gave 0.00058 grm. nitrogen as  $HNO_3$  and 0.00058 as  $HNO_2$ . 1,000 liters of coal gas charged with ammonia gave 0.01071 grm. N as  $HNO_3$  and 0.00168 grm. N as  $HNO_2$ . The combustion of 1,000 liters of coal gas charged with ammonia, in a normal atmosphere, in a Bunsen burner with air holes closed, gave 0.01595 grm. N as  $HNO_3$ , and 0.00238 grm. N as  $HNO_2$ . The combustion of 1,000 liters of ammonia free coal gas, in an atmosphere charged with ammonia, in a Bunsen burner gave 0.09393 grm. N as  $HNO_3$ , and 0.1115 grm. N as  $HNO_2$ . When hydrogen, passed over strong sulphuric acid, was burned in an ordinary atmosphere, about 0.013 grm. N as  $HNO_3$ , and 0.0003 grm. N as  $HNO_2$  were produced per 1,000 liters. When the air was thoroughly purified by passing over strong sulphuric acid, etc., no nitric acid and less than 0.00001 grm. N as  $HNO_2$  was obtained. By a still more efficient purification of both hydrogen and air the condensed water was obtained free from nitrates and nitrites. The author, in conclusion, expresses his belief that the origin of the nitrogen acids found in the condensed water procured by burning coal gas or hydrogen in air is ammonia either free or combined.

Dr. Frankland said that the experiments just detailed raised some interesting points as regards the combustion of coal gas. In the combustion of ammonia free coal gas the temperature never rose high enough to cause the oxidation of any large amount of nitrogen. An interesting experiment on the subject was the following:—If a jet of hydrogen be lighted in a glass bell jar no red fumes are

formed, but on adding oxygen to the atmosphere an increase of temperature soon produces perceptible red fumes in the bell jar. In connection with the arc of the electric light, the temperature of which must be enormously high, it would be most important and interesting to determine whether any oxides of nitrogen were formed, and in what quantity.

"On the Action of Bromine upon Sulphur," by J. B. Hannay. In former papers the author showed that when sulphur and bromine were distilled together distillates of any desired composition might be obtained, but that the residue was never free from bromine. The author in the present note attributes this retention of bromine to the sulphur passing into the viscous state, and finds that at 15° complete dissociation can be effected.

"Researches on Dyeing: Part I., Silk and Rosanilin," by Dr. Mills and G. Thomson. The authors have investigated the nature of the transaction which occurs when a vat is exhausted of its tinctorial ingredients. The experiments consisted in immersing a constant area of white silk in a solution of rosanilin acetate, etc., at a constant temperature for varying times, and determining the loss of strength of the rosanilin solution. They have arrived at the following conclusions: (1.) That when silk is dyed with rosanilin salt that salt is deposited as a whole. (2.) That a boiling weak solution of rosanilin salt may undergo dissociation so as to become quite colorless; in which state, however, the dissociating force is wholly overcome by a silk. (Silk is dyed red by immersing it in a solution containing 0.000003 grm. in 1 c.c., previously rendered colorless by boiling for half an hour.) (3.) That for periods of four days, at the ordinary temperature, a magenta vat is exhausted at compound interest. (4.) That the rate of exhaustion of a magenta vat is retarded by sodic or potassic chloride, and not improbably to an equal extent by equal weights of those chlorides.

"Comparisons of the Actions of Hypochlorites and Hypobromites on some Nitrogen Compounds," by H. J. H. Fenton. Both the above reagents act rapidly on ammonium carbamate, but as with urea, only half the nitrogen is evolved with hypochlorite, while hypobromite causes the evolution of the whole of that gas. The residue from the hypochlorite does not contain nitrogen as a cyanate, but probably in the form of sodium carbamate. Guanidin yields to both reagents two thirds of its nitrogen. The residue behaves like that from the action of hypochlorite on urea. Biuret gives one third of its nitrogen with hypochlorite and two thirds with hypobromite; the residues resemble those from urea. The author's results are given in the following table:

|               | Urea. | Ammonium Carbamate. | Guanidin. | Biuret. | Ammonia Salts. | Cyanates. |
|---------------|-------|---------------------|-----------|---------|----------------|-----------|
| NaClO evolves | 1/2   | 1/2                 | 1/2       | 1/2     | All            | None.     |
| NaBrO         | All   | All                 | 1/2       | 1/2     | All            | None.     |

In conclusion the author discusses the formulæ of the above bodies.

"Notes on two New Vegeto-alkaloids," by F. Von Müller and L. Rummel. Alstonin is obtained from the alcoholic extract of the bark of *Alstonia constricta*. It forms an orange-yellow brittle mass, of a bitter taste, melts below 100° C.; is soluble in alcohol, ether, and dilute acids, sparingly soluble in water. Dilute solutions have a strong blue fluorescence, which is unaffected by acids and alkalis. It is precipitated by the usual alkaloid reagents. Duboisin is a volatile alkaloid obtained from the leaves and twigs of *Duboisia myoporoides*, by a process similar to that employed for the extraction of nicotine. Duboisin is probably identical with Staiger's piturin. Duboisin is a yellowish oily liquid, lighter than water, with a strong narcotic odor and alkaline reaction; very soluble in ether, alcohol, and water. It is not precipitated by phospho-molybdate of soda, picric acid, or platinic chloride.

"On the Determination of Lithia by Phosphate of Soda," by C. Rammelsberg. Berzelius detected lithia in Carlsbad water by evaporating the solution of the alkalies with phosphoric acid and sodium carbonate. On treating the whole with water an insoluble phosphate of sodium and lithium remained. This double salt the author has shown to be a variable mixture of the two phosphates. Mayer, however, contradicted these results and denied the existence of a double phosphate, and contended that the above residue was pure lithium phosphate. The author has repeated his former experiments and completely confirmed them, preparing synthetically double salts having sodium to lithium as 1 to 3 or 9 to 2, and therefore the author concludes that lithium cannot be determined by Mayer's method, which is also recommended by Fresenius. The employment of this process for the estimation of lithium in micas has led to too high a percentage of lithium. The author, in conclusion, gives analyses of micas, especially as regards lithium; the lithium and sodium chlorides being separated by treatment with ether alcohol, as suggested some time ago by the author.

#### HYPOPHOSPHOROUS ACID AND ITS SALTS.

CONCERNING the preparation of the acid the author remarks that only about one-fifteenth of the phosphorus employed is converted into hypophosphorous acid, the bulk passing on to the state of phosphoric acid. He then gives a detailed account of the combinations of hypophosphorous acid with soda, potassa, ammonia, baryta, and lime. He adds that, as there seems to exist only one combination of hypophosphorous acid and lime, it will be possible to titrate neutral solutions of lime with neutral hypophosphite of soda, using reddened tincture of litmus as indicator, since an alkaline reaction must appear when the precipitation is complete. The process may be extended to the salts of lead and other metals.—*Chem. News*.

KESKOBURG and Robert have patented a process in France for obtaining indigo blue from all vegetable matters, whether in a manufactured or unmanufactured state.

"Turkis" is the name given by C. L. Schultze to a mixture of Nicholson blue and methyl green, dyed on wool in an alkaline bath.

The iron trade of Sweden is in a very depressed condition, and many workmen are being dismissed.

J. KELTSNER, of Nuremberg, has invented a new process for the preparation of ultramarine red and ultramarine violet.

1

The \* indicates that the Article is illustrated by Engravings.

|                                   |            |                                  |      |                                |            |                                  |            |                                 |      |                               |      |
|-----------------------------------|------------|----------------------------------|------|--------------------------------|------------|----------------------------------|------------|---------------------------------|------|-------------------------------|------|
| Aboriginal relics                 | 3066       | Babbage's analytical engine      | 3063 | Cables, submarine              | 3430       | Combustion, products of          | 3277, 3281 | Dyes, alizarine                 | 3159 | Farming, dynamite in          | 3219 |
| Abortion in cows                  | 3102       | Balloon, lamp transfer in        | 3103 | Cadaveric alkaloids            | 3187       | Combustion of gases              | 3063       | Dyes and colors                 | 3060 | Farming, English see American | 3219 |
| Accidents from machinery          | 3102       | Bag-nylon, how destroyed         | 3106 | Calcic chloride                | 3187       | Commerce, pump                   | 3074       | Dyes at Exhibition              | 3061 | Farming implements at Exh'n   | 3219 |
| Acetic acid in vinegar            | 3106       | Bag-net and Paris green          | 3214 | Calc salt manufacture          | 3280       | Commerce, obligations to         | 3103       | Dye-stuff, manufacture and uses | 3130 | Fanning mill, elevator, etc.  | 3243 |
| Acetic acid, phosphorus in        | 3417       | Baker's recipes                  | 3167 | California seaweeds, iodine in | 3265       | Commissioner of Exhibition       | 3285       | Dynamite in agriculture         | 3136 | Fatherless race               | 3243 |
| A etc ether                       | 3230       | Balloon history                  | 3419 | Calomel                        | 3265       | Communities, industrial          | 3435       | Dynamite-electric machine       | 3187 | Feed, boiler                  | 3203 |
| Aid, formic                       | 3061       | Balloon, Paris Exhibition        | 3419 | Cameras, making, imp'd         | 3243       | Compas ator, color, for analysis | 3215       | Dynamite-lec. mach., gramme     | 3465 | Feed-water heater and conden  | 3203 |
| Acid on surfaces, motion of       | 3280       | Balloons                         | 3419 | Cameras lucida, to make        | 3243       | Compass, reflecting              | 3215       | Dye-stuff                       | 3217 |                               |      |
| Acoustic resonance                | 3280       | Balloon of copal                 | 3288 | Campfor, liquid                | 3160, 3265 | Concrete                         | 3215       |                                 |      | Feed-water heater, improved   | 3203 |
| Adelsberg, caves of               | 3474       | Baltimore waterworks             | 3416 | Candles                        | 3210       | Concrete de Javille              | 3150       |                                 |      | Fermentation, theory of       | 3210 |
| Aerial echoes                     | 3437       | Bandages, fixed                  | 3210 | Candles, exhibit of            | 3210       | Concession on iron and steel     | 3280       |                                 |      | Fertilizers                   | 3210 |
| Aeronautics                       | 3177       | Bars, tan, removing              | 3478 | Canditic bracket               | 3210       | Condenser and heater             | 3464       |                                 |      | Fertilizer, coal-a-bos an     | 3210 |
| Africa, region of                 | 3281       | Barking trees by heat            | 3478 | Cannon, electric force         | 3210       | Conditioning mill                | 3464       |                                 |      | Fertilizers, formulae for     | 3210 |
| African                           | 3281       | Barrel, gun, beer                | 3210 | Cannons of Colorado, No. IV    | 3478       | Conditioning mill                | 3464       |                                 |      | Fertilizer, yeast and sulphur | 3210 |
| Agaric, quinoid of                | 3280       | Barrel, large                    | 3210 | No. V                          | 3478       | Conduction, heat, in soils       | 3283       |                                 |      | Fiber, bleaching of           | 3210 |
| Age, remarkable                   | 3284       | Basin, measurement               | 3284 | Caoutchouc                     | 3280       | Confectioners' recipes           | 3210       |                                 |      | Field gun, steel              | 3210 |
| Age, stone, of to-day             | 3284       | Basket-carrier, the              | 3284 | Capillary                      | 3247       | Congress, hygiene                | 3245       |                                 |      | Filtering elements            | 3210 |
| Agricultural implements           | 3216       | Basket carrier, insect           | 3284 | Carbolic acid, medical uses    | 3210       | Construction, fireproof          | 3214       |                                 |      | Finals of Exhibition          | 3210 |
| Agriculture, dynamite in          | 3216       | Bathing, car injury from         | 3289 | Carbolic acid, reaction, new   | 3474       | Consumptives, climate for        | 3280       |                                 |      | Fire alarm                    | 3210 |
| Agriculture, pavil. of Spanish    | 3403       | Batteries, simple                | 3283 | Carbonate of soda              | 3280       | Contagion in disease             | 3280       |                                 |      | Firearms, metal for           | 3210 |
| Agriculture, potash in            | 3102       | Battery, new                     | 3213 | Carbonate of soda              | 3280       | Conveiences, modern              | 3280       |                                 |      | Fire-bush                     | 3210 |
| Agriculture, products of Cyprus   | 3245       | Battery, single lig              | 3402 | Carbonic acid and ultramarine  | 3215       | Copper, alloy, condition         | 3217       |                                 |      | Fire-damp detector            | 3210 |
| Agriculture, ordinary of          | 3448       | Beacons, lighting sea            | 3280 | Carbonic acid, absorption      | 3215       | Copper and silver extraction     | 3440       |                                 |      | Fire-proofing                 | 3210 |
| Air, compressed, machines         | 3448       | Beans, prepared                  | 3448 | Carbonic acid, absorption      | 3215       | Copper, condition                | 3217       |                                 |      | Flouring mill, Niagara Falls  | 3210 |
| Air, compressed, in mines         | 3213       | Bees, culture, rise and progress | 3448 | Carbonization of wood          | 3287, 3285 | Copper, new modification         | 3218       |                                 |      | Flouring mill, cover use for  | 3210 |
| Air temperature                   | 3448       | See exhibition, British          | 3287 | Carbonizing apparatus          | 3287       | Copper, pavilion of              | 3288       |                                 |      | Fire-hole ring rivet          | 3210 |
| Air ships                         | 3177       | See, most profitable             | 3143 | Carbon, oxychloride of         | 3280       | Copper plates, hardening         | 3288       |                                 |      | Fire-iron of L. M. M.         | 3210 |
| Air, electric fire                | 3434       | Bees                             | 3281 | Carbon, vapor, for prepar      | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Air, electric power in            | 3434       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Albumen, regeneration of          | 3186       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Albumen, regeneration of          | 3186       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alcohol                           | 3286       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alcohol detection                 | 3217       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alcohol in sick room              | 3285       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alcoholic fermentation, theory of | 3417       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alcohol, oxalic acid and          | 3153       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Algerian court at Exhibition      | 3210       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Algerian Exhibit                  | 3446       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Aliments, Exhibition              | 3461       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Aliments at Exhibition            | 3205       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alkalies, test for                | 3413       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alkaloid, new                     | 3473       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alizarine                         | 3159       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alizarine, brown                  | 3150       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alizarine carmine                 | 3286       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alizarine colors                  | 3289       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alkaloids                         | 3185       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alkaloids, cadaveric              | 3157       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alkaloids and ox                  | 3158       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alum                              | 3286       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Alumin. & gallium alloys          | 3133       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Aluminum oxidation                | 3170       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Amalgamation in silver mill       | 3465       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| America                           | 3284       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| American medals                   | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| American awards, Exh'n            | 3370       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| American beef for England         | 3442       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| American beer                     | 3300       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Amer. competition with Eng.       | 3287, 3288 | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Ammoniacal citrates               | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Ammonia, distribution of          | 2.66       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Ammonia estimation                | 3125       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Ammonium tri-iodide               | 3185       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Analyses of foods                 | 3277       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Analysis, general                 | 3277       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Analysis, quan. spec              | 3277       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Analysis, human and animal        | 3277       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Aniline black                     | 3231       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Aniline black, an                 | 3236       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Aniline salts                     | 3158       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Animal intelligence               | 3289       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Animals, human relation to        | 3287       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Anthrax                           | 3217       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Anthrax, new                      | 3167       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Anthrax, crude                    | 3441       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Anthrax, epidemic                 | 3441       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Anthrax, human                    | 3416       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Anthrax, preparation              | 3416       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Anthropology                      | 3287, 3288 | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Anthropology at Exhibition        | 3413       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Antidote for arsenic              | 3289       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Antidote for mercury and lead     | 3289       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Antimony & arsenic separation     | 3289       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Antimony, tartarized              | 3289       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Antiquities from Peru             | 3446       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Antiquities from Thebes           | 3405       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Antiquities, Peru                 | 3418       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Antiquity                         | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Apes, anthropoid                  | 3287       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Apocryphs, El Dorado for          | 3467       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Apple-auce, dried                 | 3402       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Art, intelligence of              | 3289       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Art, scientific, spectrum of      | 3289       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Aquarium, Tyne-mouth              | 3274       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Archaeological discoveries, Mo.   | 1099       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Archaeology, American             | 3077       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Archaeology in Ithaca             | 3275       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Archaeology of Peru               | 3418       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Architectural                     | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Architectural, general            | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Architectural                     | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Architectural at Exhibition       | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Architectural, Jewish sect.       | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Architectural of Old St. Paul's   | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Architectural, general            | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Architectural                     | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
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| Architectural, Jewish sect.       | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Architectural of Old St. Paul's   | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
| Architectural, general            | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |
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| Architectural, Jewish sect.       | 3280       | Bees, care of                    | 3281 | Carbonyl chloride              | 3280       | Copper, test for                 | 3245       |                                 |      | Fire-proof construction       | 3210 |

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